PROCEEDINGS

TENTH ANNUAL MEETING

NORTH CENTRAL WEED CONTROL CONFERENCE

December 10, 1953

and

Abstracts of Papers Presented

at

First National

WEED CONTROL CONFERENCE

December 8, 9, 1953

Kansas City, Missouri

1954 MEETING

FARGO, NORTH DAKOTA

DECEMBER 7, 8 and 9

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PROCEEDINGS OF THE TENTH ANNUAL MEETING

OF THE

NORTH CENTRAL WEED CONTROL CONFERENCE

Kansas City, Missouri

December 10, 1953

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PREFACE

The Proceedings of the Tenth Annual Meeting of the North Central Weed Control Conference are a record of the formal papers and reports of the committees of the Conference.

The North Central Weed Control Conference acted as host to the First National Weed Control Conference and this Tenth Annual Meeting was held in conjunction with the national meeting.

Abstracts of papers presented at the First National Meeting and the complete text of papers presented at the North Central Meeting are contained herein.

Additional copies of this proceedings are available at $2.00 per copy from F. W. Slife, Department of Agronomy, University of Illinois, Urbana, Illinois.

PROGRAM AND TABLE OF CONTENTS

Tuesday Morning, December 8, 1953

General Meeting, Municipal Auditorium: Chairman: R. H. Beatty

Welcome to Kansas City
Hon. William E. Kemp, Mayor
Opening Remarks
E. P. Sylwester, Chairman, Association of Regional Weed Control Conferences. 1
Scope of Research in Weed Control
B. T. Shaw, Administrator, Agricultural Research Administration, U.S.D.A., Washington, D. C. 3
Extension Work with Respect to Weed Control
P. V. Kepner, Assistant Administrator, Agricultural Extension Service, U.S.D.A., Washington, D. C. 4
Regulatory Aspects in Weed Control
W. S. Ball, California State Department of Agriculture, Sacramento, California. 4

Tuesday Afternoon, December 8, 1953

General Meeting, Municipal Auditorium: Chairman: W. B. Ennis, Jr.

Influence of Herbicides on Enzyme Systems
D. T. Wort, University of British Columbia, Vancouver, British Columbia. 6
Metabolism of 2,4-D by Micro-organisms and Higher Plants
R. L. Weintraub, Chemical Corps Biological Laboratories, Camp Detrick, Maryland. 6
Mode of Action of Phytotoxic Oils
J. Van Overbeek, Shell Oil Company, Modesto, California. 7
The Relation of Structural Configuration to the Herbicidal Activity of the Carbamates
W. C. Shaw and C. R. Swanson, Division of Weed Investigation, U.S.D.A., Beltsville, Maryland. 7

Section I. Regulatory Chairman: V. W. Woestemeyer

Control of Weeds on Federally Owned or Controlled Land
C. J. Gilbert, State Weed Board, Brookings, South Dakota 8
Report of Committee on Uniform Weed and Seed Laws
D. W. Lambert, Division of Noxious Weeds, Department of Agriculture and Inspection, Lincoln, Nebraska. 9
Local Problems in Regulatory Phases of Weed Control
W. S. Ball, California State Department of Agriculture, Sacramento, California. 9
Talk at North Central Weed Conference
J. H. Minks, Blue Earth County Weed and Seed Inspector, Mankato, Minnesota. 10
Is Education Enough?
E. P. Sylwester, Iowa State College, Ames, Iowa. . . . 11

Section II. Water Weed Control Chairman: F. L. Timmons

Control of Aquatic and Marsh Weeds in Wildlife Habitats
A. C. Martin, U. S. Fish and Wildlife Service, Laurel, Maryland 12
Chemical Weed Control Investigations on Some Important Aquatic Vascular Plants
E. T. Oborn, U.S.D.A., Division of Weed Investigations and U.S.D.I., Bureau of Reclamation, Denver, Colorado 12
Control of Submerged Water Weeds in Irrigation Canals
J. M. Hodgson, U.S.D.A., Division of Weed Investigations, Bozeman, Montana. 13
Control of Emergent Aquatic Weeds in Irrigation Canals
F. L. Timmons and W. O. Lee, U.S.D.A., Division of Weed Investigation, Logan, Utah. 14

Wednesday Morning, December 9, 1953

Section I. Control of Woody Plants Chairman: C. E. Fisher

Use of Radio-active Isotopes of 2,4-D in Brush Control
A. S. Crafts, University of California, Davis California 14
Control of Woody Plants with Chemicals on Range and Pastureland in the South
A. H. Walker, Extension Range Specialist, Texas A & M College, College Station, Texas 15
Control of Wood Plants on Industrial Sites with Non-growth Regulator Chemicals
Arne Carlson, Du Pont Company, Wilmington, Delaware 15
Control of Woody Plants on Industrial Sites with Growth Regulator Chemicals
L. L. Coulter, Dow Chemical Company, Midland, Michigan. 16
New Developments in Brush Control Research
R. E. Larsen, Division of Weed Investigations, U.S.D.A., Columbia, Missouri. 16
The Importance of Brush Control to REA Borrowers
C. J. Waldron, R.E.A., Washington, D. C. 17

Section II. Weed Control in Horticultural Crops Chairman: R. D. Sweet

Weed Control in Onions in Organic Soil
Victor Guzman, Everglades Experiment Station, Belle Glade, Florida. 17
Promising Herbicidal Methods for the Control of Weeds in Seed Onions
R. L. Hawthorn and F. L. Timmons, Agricultural Experiment Station and BPI, Logan, Utah. 18
A Weed Control Program for Muckland Onion Growers
R. E. Nylund, University of Minnesota, St. Paul, Minnesota. 19
Chemicals for Onion Weed Control
D. Y. Perkins, Cornell University, Ithaca, New York. 19
Five Years Research on Weed Control in Indiana Onions
G. F. Warren, Purdue University, Lafayette, Indiana 20
A Quantitative Study of the Competition of Weeds with Vegetable Crops
C. A. Shadbolt, University of Wisconsin, Madison Wisconsin 21
Fate and Activity of Herbicides in Soils
R. E. Ogle and G. F. Warren, Purdue University, Lafayette, Indiana. 21
A Theory for the Selective Mechanism of Chloro-IPC
S. K. Ries, Michigan State College, East Lansing, Michigan 22
Some Responses of Several Horticultural Plants to CMU, 3-CIPC and Dalapon Under Greenhouse Conditions
R. F. Carlson, Michigan State College, East Lansing, Michigan. 23
Chemical Weed Control of Some Ornamental Crops
Arthur Bing, Ornamentals Research Laboratory, Farmingdale, L. I. 23
Chemical Weeding of Potatoes
E. K. Alban, Ohio State University, Columbus, Ohio. . 23
Chemical Weed Control in Peas
E. T. Anderson, University of Manitoba, Winnipeg, Manitoba, Canada. 25
Chemical Weed Control in Peas
K. P. Buchholtz, University of Wisconsin, Madison Wisconsin. 26
Chemical Weed Control in Peas
M. W. Miller, Birdseye Research Laboratory, Albion, New York. 26
Weed Control in Dry Field Peas
C. I. Seely, University of Idaho, Moscow, Idaho. . . . 27

Wednesday Afternoon, December 9, 1953

General Meeting: Chairman: C. I. Seely

Absorption and Translocation of Herbicides
A. S. Crofts, University of California, Davis
California. 28
Translocation of C.M.U.
J. R. Haun and J. H. Peterson, Du Pont Company,
Wilmington, Delaware. 28

Leaf Waxes and Herbicidal Sprays
L. E. Mueller and W. E. Loomis, Department of
Botany, Iowa State College. 76

Section I. Extension Education Chairman: William Harvey

Trends in Teaching Weed Control
Oliver C. Lee, Extension Botanist, Purdue
University, Lafayette, Indiana. 29
Teaching Aids in Weed and Seed Identification
Lloyd R. Wilson, Extension Weed Specialist, South
Dakota State College, Brookings, South Dakota. 30
A Statewide Extension Program in Weed Control
R. B. Widdifield, Extension Agronomist, North
Dakota Agricultural College, Fargo, North Dakota. . . 30
The Role of Extension Agents and Action Agencies in a
Weed Control Program
George M. Briggs, Extension Agronomist, University
of Wisconsin, Madison, Wisconsin. 31
Responsibilities of an Extension Weed Specialist
W. A. Harvey, Extension Weed Control Specialist,
University of California, Davis, California. 33

Section II. Experimental Techniques Chairman: K. P. Buchholtz

Screening Breeding Stocks for Herbicidal Tolerance
R. S. Dunham, University of Minnesota, St. Paul,
Minnesota. 33
Formulation Problems with Herbicidal Chemicals
V. H. Freed, Oregon State College, Corvallis,
Oregon. 34
Environmental Control Chambers for Herbicidal Studies
C. L. Leinweber, Texas A & M College, College
Station, Texas. 34
Techniques for Studying Weeds in Flax
Lyle Derscheid, South Dakota State College,
Brookings, South Dakota. 35
Weed Sampling Techniques in Pastures
D. L. Klingman, Division of Weed Investigations,
U.S.D.A., Columbia, Missouri. 36
Weed Control Evaluation in Wheat
L. W. Rasmussen, State College of Washington,
Pullman, Washington. 37
Experimental Techniques for Chemical Weed Control Work
W. C. Jacob, Cornell University, Ithaca, New York,
and S. K. Ries, Michigan State College, East Lansing,
Michigan. 38

Wednesday Evening, December 9, 1953

Banquet--Gold Room, Hotel Muehlebach
C. J. Gilbert, President, North Central Weed Control Conference,
Presiding
Guest Speaker: Dr. Alfred P. Haake, Author, Lecturer and Consultant
to General Motors, Parkridge, Illinois
Presentation of Awards. 38

Thursday Morning, December 10, 1953

General Meeting: Chairman: C. J. Gilbert

Weed Control in Fall-Sown Grain
W. M. Phillips, Division of Weed Investigation,
U.S.D.A., Hays, Kansas. 39

Controlling Weeds in Soybeans
F. W. Slife, University of Illinois, Urbana, Illinois 41
Weed Control in Sorghum
W. C. Elder, Oklahoma A & M College, Stillwater, Oklahoma, Weed Control in Corn 43
Chairman: O. C. Lee, Purdue University, Lafayette, Indiana
Effect of Various Levels of Weed Infestations and Economic Consideration of Weed Control
D. W. Staniforth, Iowa State College, Ames, Iowa. 44
Temperature and Humidity Effects on Pre- and Post-emergence Applications of 2,4-D and Dinitros
E. K. Alban, Ohio State University, Columbus, Ohio. 46
Varietal Responses to Herbicides
K. P. Buchhooltz, University of Wisconsin, Madison, Wisconsin. 47
Field Observations of Weed Control in Corn
F. W. Slife, Illinois. 49
Field Observations of Weed Control in Corn
C. J. Willard, Ohio. 50
Field Observations of Weed Control in Corn
J. R. Fleetwood, Missouri. 50
Field Observations of Weed Control in Corn
E. P. Sylwester, Iowa. 51
Field Observations of Weed Control in Corn
O. C. Lee, Indiana. 52

Thursday Afternoon, December 10, 1953

General Meeting: Chairman: H. E. Wood

Control of Weeds in Pastures
D. L. Klingman, Division of Weed Investigations, U.S.D.A., Columbia, Missouri. 53
Panel--New Chemicals
Chairman, C. E. Minarik, Chemical Corps, Biological Laboratories, Camp Detrick, Maryland. 56
Phenyl dimethyl urea--D. D. Hemphill, University of Missouri, Columbia, Missouri. 56
Dalapon--K. C. Barrons, Dow Chemical Company, Midland, Michigan. 57
N-1 Naphthylphthalamic acid--G. F. Warren, Purdue University, Lafayette, Indiana 58
4-Chlorophenoxyacetic acid and 3,4-dichlorophenoxyacetic acid--Lyle Derscheid, South Dakota State College, Brookings, South Dakota. 59
Analogs of 2,4-dichlorophenoxyethyl sulfate--J. P. Mahlstede and E. L. Denisen, Iowa State College, Ames, Iowa. 60
Amino triazole--Richard Behrens, U.S.D.A., College Station, Texas. 61
Certain Uses of Urea Herbicides--V. J. Fisher, Du Pont Co., Manhattan, Kansas. 62

Committee Reports:

Research. 63

Terminology. 74

Resolutions. 76

Registration List. 77

List of Commercial Organization Members. 87

List of Exhibitors. 88

OPENING REMARKS

E. P. Sylwester
Iowa State College, Ames, Iowa

First of all I want to thank you in behalf of the Association of Regional Weed Control Conferences and in behalf of our host Conference - The North Central Weed Control Conference, and also in behalf of the Program Committees of the Association and the North Central Conference, for the very fine attendance present here this morning. We, also, want to thank the Mayor of Kansas City for his fine remarks and for extending the hospitality of the City to our group. I, also, want to thank the National Program Committee consisting of Dr. Lovvorn and Dr. Minarik, the presidents of the Conference, especially C. J. Gilbert of our North Central Conference, for cooperating so splendidly and unstintingly that this First National Weed Control Conference might be a success. I, also, want to thank Mr. Fleetwood, and Mr. Hemphill for their efforts in making these arrangements possible. I, also, want to thank, in advance, all of the people who will contribute to these programs. Almost without exception, they responded generously, busy as they were, to help make this first National Weed Control Conference a success. We owe all of the people who have had the remotest part to play in making this Conference possible, a hearty vote of thanks.

Needless to say, this first National Weed Control Conference is the realization of the dreams of many weed workers throughout the United States and Canada. It is an entirely new venture. Ever since the individual conferences were organized, there has been a discussion as to the desirability of holding a Conference at which people from all over the United States and Canada could gather and exchange ideas, compare notes, discuss mutual problems and gain added inspiration for the tremendous task of weed control which lies ahead of all of us.

This first National meeting then, which is sponsored by the Association of Regional Weed Control Conferences in cooperation with the North Central Weed Control Conference, as we envision it now, we hope is the beginning of a period where from time to time - say every 2, 3, or 4 years, we can repeat this meeting on a National basis. How often such meetings should be held in the future, the places where they should be held, should be decided by the officers of the Association of Regional Weed Control Conferences. That group is made up of the presidents and the vice-presidents of the various Conferences. So that should automatically mean that the planning of joint conferences in the future should take place so that they will be well integrated with the meetings of the respective conferences. You, as members of your respective conferences, should let your conference president know your wishes so that he can act accordingly in the future. As we envision, at the present time, this National Weed Control Conference is not in any way, shape or form, going to replace any of our Regional Meetings. We have far too many problems in our own areas that warrant attention, which need thorough research and discussion at our conferences every year. All of you have attended your own Regional Conferences in the past and have had two to three full days of programs. Here we have tried to bring together what our joint Program Planning Committees believe to be outstanding research, regulatory, Extension and industrial men to share with each other their experiences. When you look at this program, you will see many men of National repute. There were very few of us who realized when we first met in our own Weed Control Conferences that in approximately 10 years we would have such a formidable array of talent and men - all dedicated to the task of weed control. The men who actually appear on these programs are, we believe, outstanding, but there are many others who through their hard work and dedication to the task of weed control deserve to be on such a program. We have purposely gone light on selecting members of our own Conference, because we felt that here was an opportunity to hear men of National repute from outside of our own Conference. I want to assure you that everyone who has had anything to do with this program has given his utmost cooperation to make this meeting a success. Perhaps as we go on through the years, other men present here, should be given an opportunity to appear. After all, this is a new venture. We had no pattern to follow. The only objective was to put together a meeting which will give our constituents more technical know-how and more enthusiasm for their jobs. We are meeting for a single purpose, namely, better weed control, to help stem the tide of one of agriculture's most devastating saboteurs. This program is not perfect. To some it may be too long, to others too short. For some it may mean a lot of new information, for others, not so much. For some, it will mean too much emphasis on certain things, to others, not enough. There are many problems which had to be left untouched. We hope that future conferences of this type will help enlighten us on some of the things we have, of necessity, to leave out this year. One of these, I might mention, is the Public Health angle of weed control. Another is the control of weeds in cotton, and we could mention many others. It has been the thinking of the Association of Regional Weed Control Conferences to have this National Conference under the auspices of the Association meet jointly with one of the four Conferences in the years to come. We learn by doing. We made some mistakes this time, some of which are apparent, others are not. At any rate, we hope we have set a pattern here which, I believe, all of us hope will continue to be followed, improved, of course, - better in every way at such a time and at such place as the Association of Regional Weed Control Conferences, in conjunction with the established conferences, sees fit to promote. Because next time there will be more or less of a pattern, we will expect and I am sure we will get, a more informative and better meeting. All circumstances considered, it seemed best this time to hold it in conjunction with the North Central Conference. Our people have been most cooperative.

The Association of Regional Weed Control Conferences was, like the conferences already in existence, formed because there was a need for such an organization. At the time when the founding fathers formed the separate conferences and later on the Association of Regional Weed Control Conferences, there was no organization which met those needs. In retrospect, I admire the courage and the foresightedness which these pioneers in weed control exhibited even though it is only a few years ago. Your conferences and the Association of Regional Weed Control Conferences is beset with many problems. That is as it should be. If you have an organization which hasn't any problems, it becomes

smug in appearance and just another organization. If an organization has no problems, there is no reason for its existence. If there are no growing pains, you have a static organization, and very seldom, if ever, is a static organization accomplishing very much. The Association of Regional Weed Control Conferences can vitally concern itself and solve some very definite problems. In the first place, there is the question of future meetings of this type. Should they be held separately or should they be held in conjunction with the conferences? We argued this point loud and long and to us it appeared that this method of arrangement where we accept the hospitality of one of the groups, this seemed to us the logical approach at least this time. We hope it will be continued. But lets proceed slowly and firmly. There is the matter of the selection of people on National programs and that, I can assure you, is a tough assignment. Not even the most optimistic weed workers ten years ago dreamed of such a wealth of material, energy and enthusiasm for the arduous task of weed control as we see exhibited here today, and our organization is growing and weed control is becoming ever more important, always more effective, always more profitable to the eventual user of these methods on the land. The future holds much in store. New methods, new chemicals, new workers, new angles - all challenge us in the future. In the future also we must continue to give full partnership to our Canadian workers, not associate membership or membership by influence.

In the matter of weed control terminology, our Association can perform a valuable task. We have made a tremendous amount of progress. Uniformity is beginning to appear. After all, we are no longer killing weeds or farming as they did in Grandfather's time. We are farming in a fast moving, atomic age, crashing supersonic barriers and traveling from coast to coast non-stop. Terminology should be uniform and if our four conferences can agree on uniform terminology and our Association sponsor such terminology, that will be a step in the right direction. This is necessary for chemicals and weed names.

We have another problem concerning the Weed Journal. What is the future of this publication? It must be continued. What is its future? Are we willing to support it - both financially and by means of publishable material? If it is really to be taken to heart it must be of interest to all of its subscribers, industrial men, research men, regulatory men, Extension men and county weed commissioners. To make it such is a real task and a real challenge. We owe Dr. Sweet, Dr. Lovvorn, and Dr. Shaw a vote of thanks for carrying on so nobly so far. And we owe Dr. Minarik a real vote of thanks for volunteering to step in and become the editor of weeds. We need to improve our setup to help him.

So we have a lot of problems. I have touched on only a few. New ones will arrive as new chemicals and new methods of control come into existence. All of us must be constantly alert, have our ears to the ground to ascertain what needs to be done, then to go ahead and unselfishly give and take ideas which will help us in our programs at home. We should be happy that we have problems, because it is a challenge to solve those problems. When we think of the tremendous progress that has been made in the entire realm of weed control, how at the present time from all over the Nation, can come men dedicated to this stupendous task, we should be happy to belong to a weed control organization which has meant so much and done so much for all of us.

But the esteem in which these conferences are held is also another challenge. We must carefully guard the progress that we have made toward unification of our thinking along National and Regional weed control lines. In these days of unsettled conditions, supersonic planes, mass means of education and travel, we cannot sit complacently in our own areas thinking that we have arrived at perfection. All of us have a long way to go. In our future thinking, everything should be done that possibly can be done to further weed control along our individual conference and national conference lines. One of our weed commissioners told me in discussing this meeting, "I am going to be there. I don't care if 9/10's of this meeting is basic research and is a little bit beyond my grasp. I can still get enough good out of the meeting to make it worth my while. I have found that regardless of what kind of a meeting I go to, I can usually find something which is of interest and benefit to me." I think all of us can profit by that statement. I firmly believe that a National Meeting held every 2, 3, or 4 years has a valuable function to perform. I like to meet workers from other areas. To many of us, a good many of these workers have been mere names. We have heard about them. Now we have a chance to meet them. We have a chance to hear them. We have a chance to become imbued with their spirit in weed control. I just as firmly believe that our Regional Conferences must be continued annually or else we will lose contact and contunity. The reason that these Regional Conferences have been so eminently successful is because they have met and fulfilled a need which existed and which couldn't be filled by any other then existing organization. These conferences came into being as a logical solution for that means. They grew from Grass Roots, not from the top down. They arose because there was a need for them and they have fulfilled that need. We hear that these conferences have fulfilled their purposes, that we should abandon them or amalgamate them with something bigger. If we abandon them it will be a sad day indeed for weed control. If we amalgamate we lost our identity. We've got a vital, stable growing concern and we want to keep it that way. Where could we go today, for instance, if more factual information on basic and applied weed control than we can from the proceedings, research reports and from meetings of this type. Where can you as research people, as Extension people, as regulatory people and as the industrial people go to one meeting and find every single one present interested in one thing, namely, weed control. The answer is obvious - no place. So far as I am concerned, that is the mandate to improve our Regional Conferences and to strengthen our National Association programs. We must bear allegiance to the cause of Weed Control. We must constantly be on the lookout to improve our existing organizations. Remember, we have this organization and the old proverb of "A bird in the hand being worth several in the nebulous bush" still applies. So these meetings, Regional and National, mean much to all of us and should be continued. Let's not come here just for the sake of a meeting. Let's be prepared to share unselfishly and unstintingly with out fellow workers. Share our experiences concerning the eradication and control of one of the worst saboteurs of American agriculture. Let's come to these meetings and rub elbows with fellow workers who are the best in the business of weed control. Then we can carry back to our own

areas the experiences of other people from throughout the length and breadth of the United States and Canada.

Our constituents back home thus receive the benefit of the best thinking in the subject of weed control. Let's make this conference one of the best workshops you have ever attended. If you make this a real weed control workshop rather than just another meeting, if you carry back from here new zeal to do your job, then you will be extremely well repaid for the time spent here. And when you get back home, impart to your constituents the zeal of these workers whom you can hear and see here. If you do that, your states, your areas and your constituents will benefit and the future of our Regional Conferences and our National Association will be assured, and with that assurance comes a more stable, more profitable agriculture, and with more of the losses caused by weeds eliminated, our society will enjoy the higher standard of living.

SCOPE OF RESEARCH IN WEED CONTROL

Byron T. Shaw, Administrator
Agricultural Research Service
Washington, D.C.

Abstract

Weeds compete so successfully with cultivated plants that despite all that farmers do, the annual reduction in the value of crops and pastures due to weeds is estimated at about 3 billion dollars. To this must be added the cost, estimated to be 1 billion dollars a year, of the various things done, including tillage, to combat weeds.

Despite the high cost of weeds today, we can see considerable progress over the last two decades in checking the losses, which had become quite striking by World War I and the years afterward.

It was a serious infestation of bindweed in the Thirties that brought matters to a head. Research help was provided starting in 1935. By 1950 all weed investigations were combined administratively in the Department.

The discovery about 10 years ago that certain plant modifying chemicals, especially 2,4-D, could be used for killing weeds selectively, was the turning point. Since then many new chemicals and control techniques, scientifically sound, have been developed.

Actually, of course, knowledge about the selective action of chemicals on plants developed over many years. For example, in 1908, H. L. Bolley, of North Dakota, after 12 years research with various chemicals, predicted selective weed control as a regular profitable farm operation.

However, the past 10 years have established chemicals as proved supplemental tools for weed control in many field crops and on pastures and meadows. Satisfactory methods have been worked out for chemical weed control in a dozen horticultural crops. Chemical control also is becoming more important in brush clearing on non-agricultural lands, for removing mesquite on Southwestern rangelands, and clearing irrigation canals of weeds.

Both fundamental and applied research has been necessary.

Four groups of herbicides now available indicate the trends of development. The first group consists of the phenoxy compounds. The second group consists of the substituted phenols. The third are the carbamates, and the fourth are the substituted ureas.

For the first time it appears that herbicides are available which may be successfully applied at low pressure and low rates as pre-planting, pre-emergence, post-emergence, and soil sterilization treatments.

In many cases chemicals can reduce weed control costs considerably.

Nevertheless, chemical control is a supplemental technique. Weed scientists recognize that clean seed is a sound starting point in any weed control program; and that efficient cultural practices are essential.

Since chemical weed control is probably the most important supplementary production technique that as yet has not been fully utilized, there is need for increasing and sustained research.

Farmers need help in putting to use the precision techniques that are needed with the large number of herbicides being developed for specific purposes and plants.

No chemical we have will kill weeds on a farm without injury to some crops. We need fundamental research on the herbicides. The 1952 losses in cotton are a case in point. Advance fundamental research might have averted the damage.

There are many specific needs for additional research. For example: We need better methods of providing weed control in cereals without destroying the underseeded legumes; a chemical control for annual grasses in rice; a way to make chemical weed control in soybeans, peanuts, lima beans, and other large seeded legumes safer; ways to combat more effectively wild oats and the giant foxtail, which are serious pests in large areas; a fundamental understanding of how to control perennial weeds, and about penetration, absorption, and translocation of herbicides in plants; new findings about pre-emergence spraying so the maximum use can be made of this method; and more knowledge about the effects of herbicides on edible portions of vegetables.

These illustrate how the chemical approach to weed control is becoming more complicated. A large body of basic studies in plant physiology, ecology, agronomy, horticulture, and chemistry needs to be carried on continuously with investigations of herbicides.

The ultimate place of chemical weed control will be determined largely by the way in which the research task is carried out.

EXTENSION WORK WITH RESPECT TO

WEED CONTROL

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Washington, D. C.

Abstract

The problem of weeds and their control has been one facing farmers from time immemorial. The extent and the intensity of this problem in the future will depend, to a great degree, on the effectiveness of the work done by the respective groups represented at this conference.

The Cooperative Extension Service recognizes and accepts a major responsibility in this joint effort. It also recognizes that effective weed control demands a complex of techniques and practices rather than any one single remedy. Hence extension efforts to help speed up progress in economical weed control must, of necessity, be directed to several fronts simultaneously.

Appropriate methods of weed control form an integral part of extension's educational efforts to assist farmers with many problems, such as developing the most appropriate farm management plan and cropping pattern; pasture improvement and management programs; selection of the best combination of cultural practices for specific crops, and other complexes of farm problems.

In addition there are organized extension programs of many types carried on with respect to the control of specific weeds or associations of weeds. One of the most specific and frequently used is the demonstration wherein the county agent arranges on-the-farm demonstrations of cultural, mechanical, or chemical weed control methods at the appropriate time of year. With a check area for comparison such demonstrations are most effective teaching devices.

Also extension workers, usually State specialists, prepare many brief but explicit leaflets explaining different weed control measures. These are given widespread distribution in many ways to farmers and to handlers of weed control materials. Extension workers collaborate with the handlers of weed control materials and undertake to keep them advised of the latest techniques in order that they may advise farmers correctly.

Extensive use is also made of the local press, radio, and, more recently, television to arouse a greater interest in and concern about weed control and to develop as much familiarity as possible with effective control methods.

Extension workers also cooperate with weed control officials and, in many States, assist with organizing weed control committees and give guidance to such committees in their local programs.

The most effective assistance which extension agents can provide in terms of tangible results is, of course, personal counsel to individual farmers. However, the extent of such direct assistance is necessarily limited by the fact that for the United States as a whole each county agent and assistant agent has an average of 1,100 farmers to serve, each having a wide range of problems of concern.

With the rapid evolution of successful weed control through the use of chemicals in recent years extension agents have been giving more attention to assisting farmers and ranchers with weed control problems. During the past decade the number of farmers county agents have assisted with weed control has increased by 130 percent. However, the very rapidity of this evolution is in itself something of a retarding force in that agents are inclined to be cautious in recommending chemical controls until such have been adequately field tested. Extension's educational work on weed control will continue to become more effective as we get the various chemical controls more thoroughly field tested and their practical and economical use proven.

REGULATORY ASPECTS IN WEED CONTROL

Walter S. Ball
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Abstract

I am sure you are all familiar with the work of the regulatory group. Theirs is the most unpleasant part to play as insofar as many are concerned they may be regarded as the villain and in some instances "villain" is a tame word. Laws and regulations are necessary in the operation of any extensive program and I am going to discuss only two problems dealing with this phase of the program, realizing that one "pest control operators and hazardous materials" is of general interest; the other "feed grains and screenings" also is of interest to many of us in the regulatory field.

Those states having extensive diversified farming have encountered some very difficult problems where susceptible crops have been injured by drift of a hazardous herbicidal material. The material causing most of the trouble is, as you all know, the hormone type of herbicide.

I have corresponded with a number of states which have found it necessary to enact laws which would provide for regulations to control this problem. The laws are very similar in that they are framed to control the use and application of an injurious material. Some states have broad provisions which cover all types of injurious pesticides, while others have pointed to 2,4-D and 2,4,5-T. I am not going to bore you by going into these various provisions but will give you some little idea of the problems encountered in this field of weed control. It is unfortunate that when state legislative bodies enact laws that they do not appropriate adequate funds to enforce the provisions. Most of the letters received relative to this subject stated that they did not have adequate funds to properly enforce the provisions enacted by their legislatures.

Factually a law is no better than the manner in which it is enforced. After laws are enacted most state legislatures give their departments of agriculture the authority to promulgate rules and regulations. After public hearing where all

interested parties may appear and have an opportunity to consider the rules and be heard they are adopted. If those using hazardous materials follow the rules and regulations information is provided to prevent or at least decrease crop damage. Unfortunately some do not agree with these rules and it is this type of operator who causes most of the trouble.

It can readily be seen that enforcement is very difficult, especially when materials are applied by aircraft due to the fact that the operator can change pressure, volume and flight pattern. I know of no State which has funds available for co-pilots.

We do not wish to see any legislation enacted that will prohibit the use of a material which has proved as valuable to the national agriculture as have the hormone-like herbicides. This has been considered, as most of you know. As recent as August 3rd of this year a new cotton organization was formed in one of the states to fight 2,4-D. The group have hired the State's best known criminal lawyer to represent them. The attorney announced that he planned to file several suits against rice growers and make a fight before the legislature to abolish the use of 2,4,-D at the next regular session. The organization will be financed by an assessment of one dollar per bale of cotton. The complaints of rice growers' use of 2,4,-D came from many cotton farmers who have complained that for the last four or five years they have lost annually as high as three-fourths of their crop.

Further research and continued education are necessary if we are to continue the use of these injurious materials near susceptible crops. This is certainly a situation where prevention through research and education is far better than an attempt to establish cause of violation and to obtain a conviction. For example when several planes are operating in a large area and crop losses are caused from 2,4-D: Who did it?

Weed seed infested grain and screenings have long been a source of the dissemination of weed seed and a very important phase in weed control. Millions of dollars are spent annually for weed control in the United States with billions of pounds of weed-infested grains and screenings shipped over the country. These weed seeds may eventually become established and may possibly be the source of the establishment of a new weed in a given area. This, of course, has been the history of the introduction of many of our more serious perennial noxious weeds. There are very few state laws designed to handle this problem and those who have laws find them difficult to enforce. In some instances the grain has been held for cleaning where noxious weed seeds have been found and later the screenings permitted to move without processing.

It is unfortunate that there are no federal requirements on grains bought and moved in interstate commerce under governmental control. Much of this grain is infested with noxious weeds and it becomes the responsibility of the State to find the infested grain and take action. In one instance in California where some 165 cars of grain were destined for storage until further shipping arrangements could be made quackgrass, Russian knapweed and Canada thistle were found throughout the grain. It would seem that our government could require that the grain they purchase and handle be free of noxious weeds. It seems inconsistent that one branch of our government will move noxious weeds throughout the country and other branches such as the U. S. Engineers, U. S. Bureau of Reclamation and the Bureau of Land Management will spend thousands of dollars annually for weed control.

Federal quarantines have no provisions which will prohibit importation of noxious-weed infested grain or screenings. I am wondering how many of you are aware of the amount of screenings imported annually into the United States. From Washington, D. C. I received data compiled by the Foreign Agricultural Service relative to the importation of screenings. During the last 11½ years 2,637,930 short tons were imported; this is approximately 220,385 tons annually. Here again I would like to refer to the Federal Seed Act which in this case does not prohibit entry of screenings into the United States.

> "Section 201.223 Screenings prohibited entry. Screenings of all seed subject to the Federal Seed Act are prohibited entry into the United States except as provided under Section 201.224. Section 201.224 Screenings permitted entry. Screenings of wheat, oats, rye, barley, buckwheat, field corn, sorghum including broomcorn, flax, millet, Proso, soybeans, cowpeas, field peas and field beans may be imported, provided such screenings are not imported for seeding purposes and are so declared by the words 'screenings for processing, not for seeding' in the invoice or other papers required to be presented to the collector of customs".

Nothing is mentioned of noxious weeds and it would be very helpful if, following the names of the grains the screenings from which may be permitted, there could be added "free from noxious-weed seed".

I believe we all recognize that there is some value in screenings and that there should be some means of taking advantage of this product. The National Association of Feed Control Officials has made a thorough study of the problem and the screenings committee and screenings investigators submitted a report in 1951 to their national association. This matter has come up repeatedly at meetings of seed control officials, and feed control officials, as well as weed control officials. As yet, however, no satisfactory solution has been found, but it is certain that further attacks on this problem must be made in order to safeguard the interests of American agriculture. I believe that a great deal of credit should be given the National Association of Feed Control Officials and their committees who have been working on this problem and I feel that all of us in the field of weed control should make an effort to cooperate and assist with this problem. I am sure a great deal could be done through national action and national recognition of the problem with possible consideration of legislation. I further believe that uniformity among states would be of great assistance. Through better highways and modes of travel the nation has become much smaller and the movement of such material much more rapid.

In conclusion, the regulatory officials have a big job before them and I am sure they will wholeheartedly welcome cooperation from all other agencies. I would like to emphasize again the necessity of uniformity in laws insofar as they can be carried out on a national scope.

INFLUENCE OF HERBICIDES ON ENZYME SYSTEMS

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Abstract

Most enzymes consist of a prosthetic group (coenzyme) and a protein portion (apoenzyme). The prosthetic group, which may be metallic or organic, gives the activity and the apoenzyme gives the enzyme its specificity. The chemical combination occurs between the substrate atoms and the prosthetic group, while the protein may serve to activate the substrate by a fleeting combination with it if their molecular architecture is suitable. Enzymes are formed within the cell under the influence of genes or plasmagenes.

Mitotic irregularities which have resulted from 2,4-D treatment suggest that the herbicide may interfere with protein architecture within the nucleus itself.

Direct action of 2,4-D on the apoenzyme is indicated by the quantitative and qualitative changes in protein brought about by treatment and also by the difference in effectiveness when used on different species.

A growth regulator may have a molecular architecture similar to that of the substrate and thus be able to compete with the substrate for the apoenzyme. If the regulator-protein is stable, the protein is masked, but if substrate-regulator-enzyme complex has a lower energy of activation an increase in apparent enzyme activity results. The application of 2,4-D has been found to result in an initial increase followed by a decrease in activity of phosphorylase amylase, catalase, etc. This may well result from a substrate-regulator-enzyme complex followed by blocking as described above. Blocking may also be the result of different regulator molecules combining with both the substrate and the enzyme.

The regulator may act directly on the prosthetic group preventing its association with the apoenzyme or to form a stable regulator-prosthetic group complex. The competition for the substrate between auxin, acting as a coenzyme, and 2,4-D may explain the abnormal differentiation obtained with treatment. Substances may inhibit enzyme action by competing with the coenzyme for the apoenzyme as is the case of the sulfa drugs.

The herbicide may affect enzyme action indirectly through a changed pH, degree of hydration, or availability of the various vitamins (for prosthetic groups) and proteins for the formation of the enzyme. 2,4,-D changes the amount of riboflavin, thiamin, nicotinic acid and adenine in plants as well as the nature and abundance of amino acids.

The amount of the end product of a reaction sequence may be influenced by blocking the sequence at some intermediate point or removing such a block. The rate of respiration of some plant parts is normally limited by the capacity of the phosphorylating system. Since low concentrations of 2,4-D increase respiration the regulator may affect this phosphorylative portion of the sequence. Some suggest it may participate in phosphate transfer.

Amylase and proteolytic enzymes are sensitive to such materials as ascorbic acid, calcium pantothenate, riboflavin, etc. Variations in ascorbic acid and the vitamin B group, have been produced by 2,4-D, thus the herbicide may influence certain enzymes through other metabolites. 2,4-D stimulates the production of coumarin derivatives and these may prove toxic to the plant.

Indoleacetic acid is destroyed by an IAA oxidase system in which there are two components - a flavoprotein which produces hydrogen peroxide and a peroxidase which uses the peroxide to oxidize the IAA. Experiments have shown that lethal doses of 2,4-D decrease catalase activity and also slow growth. The enzyme catalase decomposes hydrogen peroxide into water and gaseous oxygen. Since there is less catalase activity, more of the peroxide will be available to the peroxidase component for the inactivation of IAA and decreased growth results. In cases where low concentrations of 2,4-D stimulated growth an increase in catalase was measured. This increased catalase competes with the peroxidase for the hydrogen peroxide, less IAA is inactivated and growth increases.

In review, some evidence points to a direct action on enzymes by 2,4-D, but the majority of findings support the thesis that the effects of this herbicide on enzyme systems are produced indirectly in the ways suggested above.

This paper, in full, will appear in the publication "Weeds" in the near future. Appended to the article will be found a table of 34 entries, covering the period 1948-1953, wherein are listed enzymes studied, the plant source of the enzymes, the dosage of 2,4-D applied to the plants, the effects on enzymes in the various plant parts, and the names of the investigators.

METABOLISM OF 2,4-D BY MICROORGANISMS AND HIGHER PLANTS

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Abstract

The amount of 2,4-D that has been applied to vegetation and soil during the past decade is probably well in excess of 150,000,000 pounds. As yet there is very little knowledge of the chemical transformations which this material undergoes either in the plant or in the soil although insight into these transformations might be useful in various ways.

This paper attempts to summarize the current status of research on metabolism of 2,4-D by microorganisms and by higher plants. 2,4-D labeled at various positions with radiocarbon is now being used in such studies and will doubtless prove to be a powerful tool.

Metabolism by microorganisms. Although it has been abundantly demonstrated that the

detoxication of 2,4-D in soils is due primarily to microbial action, knowledge of the mechanism of breakdown is still quite incomplete. A number of species of bacteria capable of decomposing 2,4-D have been isolated. Experiments with R. L. Walker and A. S. Newman at Camp Detrick indicate that the molecule may not be degraded completely to carbon dioxide and water. Only one of the chlorine atoms is recoverable as inorganic chloride. The other chlorine atom as well as two of the carbon atoms of the ring appear to remain as an organic compound. A provisional scheme for the decomposition will be presented.

Metabolism by higher plants. The few species that have thus far been examined appear to have quite limited capacity to metabolize the 2,4-D molecule. It is uncertain whether or not the physiological action of 2,4-D is related to the transformations which it undergoes. The only decomposition product that has been identified is carbon dioxide which arises at a slow rate from the side-chain but apparently not at all from the ring. Carbon dioxide is produced from 2,4-D at approximately the same rate by susceptible and resistant species. Nevertheless, in experiments with J. H. Reinhart, rather marked differences have been observed in the rate of carbon dioxide production by a series of corn inbred lines.

Through the use of C^{14}-tagged 2,4-D it has been ascertained that a fraction of certain of the carbon atoms becomes associated with a wide variety of plant constituents. The bulk of the metabolized 2,4-D may be recovered, however, in the form of three, as yet unidentified, products.

Transformation of 2,4-D has been shown to occur also in dormant cherry buds. The rate of transformation is quite slow, however, so that a portion of the 2,4-D may be recovered in unaltered form several months after application.

MODE OF ACTION OF PHYTOTOXIC OILS

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Abstract

The penetration of oil into the plant takes place through the stomata of the leaf. In plants with a continuous waxy cuticle, such as in many mature leaves, cuticular penetration of unfortified oil is virtually non-existent. The action of oil in cells is characterized by a marked increase in permeability of the plasma membrane. The permeability of cells of the red table beet and of maize coleoptiles as affected by pure hydrocarbons was investigated. Aromatics were more effective than olefins, and olefins more than paraffins. It was found that within each class of hydrocarbons, molecules of low molecular weight were more effective than those of larger molecular weight. Octane, for instance, permits no water uptake of the coleoptile sections. Dodecane, however, is nearly ineffective under similar conditions. Dodecne, by contrast, if of intermediate activity, while the corresponding C_{12} aromatic compound destroyed the semipermeability of the membrane completely.

In order to understand the theory of oil action, it is necessary to understand the structure of the plasma membrane. This membrane is depicted as a bimolecular layer of polar lipoids stabilized by a layer of protein on both sides. Plasma membrane is therefore a colloidal micelle and, as such, its reaction toward fat soluble materials should follow the principles found for other colloidal micelles such as those of soap and detergents. One of these principles is that of solubilization, which is the incorporation of foreign molecules within the colloidal particles. For instance, benzene molecules are "bound" between the lipophilic tails of soap micelles just like water molecules are "bound" between layers of polar groups. It is known from the literature that compounds of low molecular weight are freely solubilized, while compounds of high molecular weight are poorly solubilized. The solubilization of hydrocarbons in colloidal micelles and the effect of these hydrocarbons on the permeability of the plasma membrane appear to be quite similar. It is concluded, therefore, that hydrocarbons solubilize into the plasma membrane. By doing so, they "open up" the membrane by displacing the normal fatty molecules responsible for semi-permeability. It would thus appear that any foreign molecule capable of solubilizing in the plasma membrane will cause a leak in it. When these leaks in the plasma membrane are few, the increase in permeability may result in stimulated water uptake. When these leaks become more abundant, the permeability is increased to the point where larger molecules leave the cells; thus, semi-permeability is lost and the cell collapses.

THE RELATION OF STRUCTURAL CONFIGURATION TO THE HERBICIDAL ACTIVITY OF THE CARBAMATES

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Abstract

The study reported in this paper involved an evaluation of the herbicidal properties of over 300 carbamate derivatives including alkyl carbamates, N-phenylcarbamates, and substituted N-phenylcarbamates.

A high degree of correlation exists between molecular configuration and herbicidal activity.

Some of the carbamates which had high herbicidal activity and very low vapor activity include 2-(1-chloropropyl) N-(3-chlorophenyl)-carbamate, 2-chloroethyl N-(3-chlorophenyl)-carbamate, sec. butyl N-(3-chlorophenyl)-carbamate and 2-chloroethyl N-(2,5-dimethylphenyl)-carbamate.

Carbamates with very low vapor activity produced less crop injury and possessed longer residual herbicidal activity than carbamates with high vapor activity. However, due to slightly lower herbicidal activity than that of CIPC, slightly higher rates per acre of the low vapor activity carbamates are required to give initial equivalent weed control.

The physiological effects of the carbamates on

plant growth include inhibition of chlorophyll production in certain species, inhibition of cell elongation, inhibition of respiration, and striking cytological aberrations.

Striking differences in selectivity were associated with various derivatives. Substituting methyl groups on the ring increased the tolerance of dicots to the carbamates without reducing the effectiveness of the compounds on the grasses.

On the basis of total herbicidal activity, not including selective properties, 30 of the carbamates were more active than isopropyl N-phenylcarbamate.

CONTROL OF NOXIOUS WEEDS ON FEDERALLY OWNED OR CONTROLLED LAND

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State Weed Board
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Abstract

It has been but a relatively short time that the problem of noxious weeds on Federally owned or controlled lands, which has been a long time in being recognized, has been receiving the attention of local, state and federal authorities.

Local and state weed control authorities, laboring to assist farmers with noxious weed control, would find their efforts going for naught because these public lands on which these uncontrolled weeds were growing, would continually and repeatedly reinfest the private land. Farmers would say, "Why should I even try to keep my land free of novious weeds with that mess next to me"? "If noxious weed control is so good for us, why does not the government take care of its own weeds?" "The government spends huge sums in research and investigations to find out what will kill weeds, why don't they use some of their own medicine?" All these and other expressions have indicated the futility of trying to secure voluntary co-operation or compliance with a weed statute, near these public lands.

So, new land continually becomes infested; the problem has grown until it now will take dollars to do what dimes would have done a few years ago.

This matter came briefly to the attention of this conference in 1949; this sectional meeting discussed the problem at length in 1950; in 1951 a resolution to be sent to Congress was adopted by this section of the conference and was later adopted by the entire conference. This resolution appears in the 1951 proceedings. Delay in submission of this memorial to congress caused delay in preparation and introduction of companion measures in the U.S. Senate and U.S. House of Representatives. Due to the lateness of these bills, the committees to which these bills were referred failed to consider them.

These bills, now designated as S.B. 627 and H.R. 2115, were again introduced on January 26, 1953. The North Central Weed Control Conference board of directors last year approved the travel expense of the writer if he was called to appear before congressional committees in support of the measures. There has been no hearing held to date.

On February 26, 1953, the Director of the Budget sent a letter containing an unfavorable report to the chairman of Committee on Interior and Insular Affairs, Senator Hugh Butler of Nebraska. I have a copy of it with me and I will read it at the close of this paper if you wish.

On June 5, True D. Morse, Under Secretary of Agriculture, wrote to Congressman Clifford Hope of Kansas, Chairman of the House Committee on Agriculture recommending that the bill do not pass. I have a copy of that letter also.

On August 18, Mr. Morse wrote to Senator Butler objecting to the passage of the legislation. I have a copy of that letter and from June 5 to August 18 a most astounding difference in estimated cost is to be noted.

On October 19, Senator Mundt of South Dakota wrote a most effective letter to Secretary McKay of the Department of Interior.

I have heard an unsubstantiated report that a hearing has been very recently called on the Senate Bill.

Support in this matter has also come from officials in Minnesota and the Congressional delegation from that state; from officials in Nebraska, Iowa and possibly others. Senator Mundt and Congressman Lovre of South Dakota have kept pushing this matter and have kept it alive. The association of state secretaries and commissioners of Agriculture have endorsed this legislation. We have personally made considerable correspondence with a large number of people.

In conclusion, I wish to state that if the Department of Agriculture, Forestry Service, Indian Service, Biological Survey, Bureau of Reclamation, etc., are to be expected to do a good job in noxious weed control there must be legislation not only of a permissive nature but of a mandatory nature. Further, may I say that in my opinion the objections made by the budget director, the under secretary of agriculture, the spokesman for the Secretary of the Interior, and others are probably the most illy considered statements of officials purporting to understand and represent the welfare of our agriculture, forest, and other land areas, that could be made. They all say they are in sympathy; they desire to give cooperation and receive it; that noxious weed control is necessary and important; but they don't want to do it. The voluntary cooperation with state and local agencies which they speak of, is for the most part and by and large, non-existent and at best sporadic and frequently mostly promises. However, to those agencies and those especially fine, cooperative men who are the exceptions to the above, goes my thanks and heartfelt appreciation. I am sure this sentiment is that of most of you who are doing your best to protect our land from the noxious weed menace.

UNIFORM WEED & SEED LAWS

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Abstract

Much time and effort has been spent in the past years by both Weed and Seed Control Officials toward uniformity in their respective groups. The Seed Control Officials have proposed and adopted by their different associations with the consent of associated groups a uniform seed law and a uniform noxious weed seed list. These have been adopted by the national groups as well as regional. This has been an important step for the seed control people since the flow of our seed crops is rapidly changing from one of a limited amount of interstate movement to one in which large amounts of seed are placed in interstate movement. With this coming about, it is necessary that seed laws and noxious weed seed lists be uniform or at least standardized so that persons placing seed into interstate movement will not have 48 totally different kinds of seed laws to contend with and over 100 different noxious weed seeds to watch for.

The Weed Control Officials while not having a proposed uniform noxious weed list or a proposed uniform noxious weed law, the latter which may be very impractical; however, have adopted a Prosposed Uniform Law for Regulating the Sale and Transportation of Weed Infested Material. This proposed law was worked out with the Seed Control Officials, and since being adopted by the North Central Weed Control Officials has been adopted by the North Central Seed Control Officials, Association of Official Seed Analyists, and has been presented to the National Seed Control Officials.

The North Central Weed Control Officials have been approached on the possibility of a uniform noxious weed list - this is something that I think we should give due consideration. However, while work is being done on this, I feel that we should give our full cooperation to the Seed Control Officials and other groups in seeing that their programs as they have been set up and planned are ultimately obtained. This we can do by making available to ourselves the necessary information to keep abreast of their activities, and whenever possible to work with them so that the end results will be of benefit to both groups.

LOCAL PROBLEMS IN THE REGULATORY PHASE OF WEED CONTROL

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Abstract

The assignment given me does not include seed inspection but I consider this very important in our regulatory work and indirectly an important phase of weed control. Through enforcement of the California Seed Law the primary noxious weeds are prohibited and the secondary noxious weeds must be shown on the label when present and then comply as to tolerance. Fortunately, we have been in a position to enforce the California Seed Law quite satisfactorily. We have had the support of the California Seed Association and the seed trade in general and our California Seed Council has cooperated wholeheartedly in establishing and making necessary changes in seed legislation. I am quite convinced that, through this cooperative manner in which our law is set up and the manner in which it is enforced we have established a much higher quality of seed for planting purposes and have prohibited the establishment of many serious noxious weeds. There is still that very difficult job of regulating the farmer to farmer sales of seed for planting purposes which is a very important factor in the dissemination of weed seed. Two of the counties in California are starting such a program, primarily through service and education. One of these counties has established seed inspection not only drawing samples but actually hiring personnel that can run a sample analysis on both germination and purity. Through this service the growers in this particular county are becoming very conscious of the importance of planting clean seed. Other counties are anticipating a similar program.

Another regulation pertaining to screenings discussed from time to time for many years has been brought up to date in California. Enforcement of this regulation is bringing about a much better condition relative to seed screenings and cleanings. We feel these regulations are very important, since we are enforcing seed laws as well as setting up standards for certification of seed where necessary to clean all noxious weeds from the crop seeds before they can be sold to the public. Too little attention has been given to screenings which have been cleaned from these crops and in many cases it is known that they have been used for feeding purposes without processing or for planting in certain areas for cover crop purposes which definitely defeats the objective of forcing farmers and dealers of commercial crop seed to clean the seed offered for sale.

Quarantine, closely allied to our seed work, is not carried out as uniformly as some of us would like to have it due to the lack of manpower which makes it almost impossible to check all of the seed which moves in the State, especially grains for feed, hay and other materials which carry viable weed seed. The law does provide that all incoming shipments of agricultural products must be held for inspection and we are able to do a good job insofar as interestate movement is concerned, but intrastate movement is not adequately handled. I believe, however, that a great deal of attention should be given to quarantine work dealing with noxious weed seed and that a great deal of care should be given the manner of enforcement. Quarantine can cause much dissension among growers and the industry if inspections and enforcement are not uniform and consistent throughout the area.

In a few instances we have had funds appropriated by legislature to assist in the eradication of a few of our more serious weed pests. Those involved to date are camelthorn, wild artichoke thistle, Texas blueweed, Austrian fieldcress, and Halogeton. The provision in the Agricultural Code states in part that the Director of Agriculture shall eradicate the named weed wherever found in the State. As most of us know, "eradicate" is a very big word, especially when we have deep-rooted perennials growing under conditions which make

control very difficult, let alone eradication. Where moneys are appropriated by the State by formal agreement, the State pays one-third of the cost of eradication, the county one-third and the landowner one-third. Should the landowner refuse to pay his share of the cost, abatement procedure is invoked.

The other problem which has given the regulatory agencies a great deal of work in our area has been to establish laws and rules and regulations pertaining to pest control operators and the control of hazardous materials. Under our organizations this law is enforced by our Bureau of Chemistry. Where there has been crop injury the Bureau of Rodent and Weed Control and Seed Inspection cooperates in field inspections and we have been called in many times to testify where civil suits have been brought about by crop injury in certain sections. We cooperate with the pest control operators in giving them as much help as possible to prevent crop injury as there are many problems involved that are unanswered and other factors which enter into the use of the hormone-like materials.

Statements have been made in many areas that the use of 2,4-D should be abandoned. I do not believe that any of us agree with this statement unless it is used in an area where injury to susceptible crops appears inevitable. This has been the case in some of our grape and cotton growing sections. By rules and regulations it has been necessary to set up hazardous areas where 2,4-D or other hormone-like materials cannot be used by aircraft between March 15 and October 15, or by ground equipment only when two miles from the nearest susceptible crop.

I feel that most of us in the regulatory work are cooperating very closely with our research people as well as the men in extension service and I definitely believe that these two organizations have been most helpful through development of new materials and the proper methods of using these materials through education and demonstrations.

This briefly covers our activities and I hope that if you have any questions or wish any further discussion that you will feel free to ask.

TALK AT NORTH CENTRAL WEED CONFERENCE

J. H. Minks
Blue Earth County Weed & Seed Inspector
Mankato, Minnesota

I wish to express my appreciation for the honor given me tonight. I hope I am deserving of it. I feel there are many more in the states and provinces represented here who are just as deserving of this reward for services rendered as a regulatory worker. (In Minnesota we are known as county weed and seed inspectors.)

I am sure you will want me to say something about how we carry out the weed control program in Blue Earth County, Minnesota. However, may I say, I come from a state consisting of 87 counties each having an organized weed program, with every county having an active county weed and seed inspector. Such a program can be accomplished only where everyone cooperates, such as industry, chemical and equipment companies, who have contributed so much to make better weed control possible. The research people, the county agents, the county boards and the state department of agriculture, through its able leadership and cooperation make our weed control program successful. However, the success or failure of any local weed control program depends largely on the man or men on the firing line.

Organized weed control program. May I give you a birds-eye view of the progress we have made in our weed control program in Blue Earth County, Minnesota.

In 1945 we had no organized weed control in our county. The county weed and seed inspector spent most of his time spraying patches of field bindweed, leafy spurge and a few other noxious weeds with sodium chlorate, spread by hand, if you please. I am sure you can imagine the large area we could cover by this method, where we have thousands of acres of noxious weeds to take care of. We soon learned that this was not a "one-man-job."

With this in mind we began organizing the townships, villages and cities in the county into active assistance in our weed control program. Today, we have an active weed inspector in each of the 23 townships, 8 villages and 2 cities in the county. We now have 17 townships who appoint an assistant weed inspector on a salary basis, while 6 townships do their own weed inspection work with my assistance. Each city and village appointed their own weed inspector. I am out helping all these local inspectors with their difficult weed problems throughout the weed season. This has worked out very successfully in our county for several years. With 33 local weed inspectors working and with the modern chemicals and spray equipment available, we can handle most any weed problem, being that we now have 640 power sprayers in use in the county.

Inspectors training meeting. Before our local weed inspectors start work in the spring, we hold a one day training meeting as to the duties of the local inspector, the use of various chemicals, equipment use and instructions in a good weed control program. This, we find is very important to give these men some knowledge of the job ahead.

Problem farms. Advanced weed control programs are set up on badly infested farms during the fall and winter months for the next crop season. These control programs consist of planting control crops, chemical and cultural methods, or a combination of these over a several year period until the weeds are eradicated. This method has been very successful here and the farmers are for it, once they get started. We can raise crops and eradicate weeds at the same time.

All year round weed and seed control program. Our weed and seed control program is so geared for the past six years, that I have been employed full time. With the setting up of weed control programs in advance of the crop season, seed inspection, weed meetings with farm organizations, high school Agricultural classes, contacting township boards and planning ahead for the next season, we get the jump on the weeds before they show up in the spring.

Seed inspection. Seed inspection is one of our important jobs in the winter and early spring. We

check all railroad depots and truck terminals a number of times each seed-selling-season, plus assisting the farmer in sampling his seed, or advising him in the proper method of cleaning and tagging the seed he wants to sell. Also we check all seed known sold by peddlers. We also assist our Crop Improvement Association in sampling seed locally.

Good records. Keeping good records of all our activities is very important. We make daily contact report of number of calls and inspections we make each day. These are sent to the State Office once a week. A monthly report is made to the County Board and the County Agent of my work the previous month, which keeps them informed of the work we are doing.

Effective weed law. The progress we have made could not have been made without the effective weed law we have in Minnesota. Even without cooperation, we may enter upon any land be it Federal, State or private. The law also includes the destroying of any weed we believe necessary.

May I say again that I am fully aware of the honor I have received. I have tried to tell you of the work accomplished in Blue Earth County. We still have much to do over the years to even maintain our present position. With new kinds of weeds showing up we must work out newer methods of control. I appreciate very much your kind attention.

Summary of expenditure for weed control of townships, villages and cities.

23 townships. Wages and mileage weed inspection		$4,722.00
Weed control, township roads		3,268.47
Total		$7,990.47
8 villages and 2 cities		
Wages weed inspection	$1,384.75	
Destroying weeds	2,131.40	
Total	$3,516.40	3,516.40
		$11,506.87

County highway used for weed control
Sodium Chlorate . . . 14,000 pounds
Ester 2-4-D . . . . . 160 gallons

State highway department
Ester 2-4-D. . . . . 155 gallons

2-4-D and 2-4-5 used	7,163	gallons on farms
Sodium Chlorate used	80,600	pounds on farms
Poly-Bor used	3,100	pounds on farms
T C A used	3,400	pounds on farms

IS EDUCATION ENOUGH?

E. P. Sylwester
Iowa State College
Ames, Iowa

Abstract

An extension man's appearance on this program indicates the close working relationship that should exist in weed control between educational and regulatory people. I believe most of us agree that weed control education must spearhead our attack against our common weed enemy. Both the extension and regulatory forces must bring into active play the best advances for the control of weeds by research and industry. Weeds are one of the big five saboteurs to American agriculture. The weed menace is far too big to be handled by one segment alone.

Experiences have shown that education must spearhead the attack. This means the active participation of the Extension services in adult education. The Agricultural Extension and the Industrial Extension services in other words are the most potent carriers of the weed control information developed by research and industry to the farmer on the land. Many farmers can see the value of and have adopted good programs of weed control. The best farmers selected in your areas, as outstanding stewards of their land very seldom operate farms overrun by weeds. Education through county meetings, demonstrations, at night schools, by form letters, newspapers, farm magazines, radio and television, can and must spearhead the attack on needs. Experience has shown that not all people can be convinced equally fast. There are always laggards in any program regardless of what it is. These must be brought under control. Noxious weeds don't stop at fence lines. One bad infestation left uncontrolled can endanger the entire surrounding community. Many of our best farmers are beginning to lose heart in the fight against needs - feel as though they are losing ground. If these good stewards are not protected, it will eventually be a sad day for agriculture. We must begin to put a premium on good stewardship of the land rather than condoning slovenliness. Regulatory workers must needs spend a greater proportion of their time in educational pursuits. By doing this, they aid the educational forces. The educational forces must see to it that the statutes of the respective states are impartially and uniformly enforced. The fact that we are regulatory and extension people of our states engaged in helping stop one of the worst ravages in agriculture is a signal honor. It means that our superiors who hire us have confidence in us. But that honor also carries responsibility to do the best job we know how to do. And that's a job and not a position. Education is vital and necessary. So is regulatory work. One without the other can do a great amount of good. But these two forces must work together harmoniously if the greatest amount of good is to be accomplished. It isn't enough to get 90 percent of the people following good weed control programs voluntarily. They must all follow them, otherwise the conscientious work of the majority will be brought to naught by the action of a few. So education is as vital as law enforcement, and law enforcement is as vital as education. Only the two working together can spell the day of better weed control for our people.

CONTROL OF AQUATIC AND MARSH WEEDS IN WILDLIFE HABITAT

Alexander C. Martin
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Abstract

Control of wetland pest plants in wildlife habitat is a foreign field to most weed workers so the why and how of it may need some explaining. With expanding agriculture and industry taking over more and more marsh and aquatic habitat, the situation is becoming critical for some kinds of wildlife. If future generations are to share in the healthful outdoor recreation that millions of fishermen and hunters enjoy nowadays, suitable places for game fish, wild ducks, and geese to feed and breed will have to be provided. A partial solution of the problem is to make the best possible use of wetlands that are left. This includes control of marsh and aquatic weeds.

Public interest in these matters has grown rapidly in recent years. Most State game commissions are now engaged in projects on development of wetland habitats and several are waging campaigns against marsh and aquatic weeds. The Fish and Wildlife Service is conducting weed control on thousands of acres and has made investigations into weed control procedures, both in fish ponds and waterfowl marshes. Publications resulting from these studies include: Fishery Leaflet 344, "Control of Aquatic Plants in Ponds and Lakes", issued in 1953.

It is generally recognized that though dense submerged growths are commonly useful to waterfowl, they are undesirable in fish ponds. Excessive aquatic vegetation can be controlled either by use of fertilizers or by herbicides.

Inorganic fertilizers have proved effective for weed control in fish ponds of the Southeast. The fertilizers promote growth of unicellular algae which in turn shade out other plants and also furnish food for fish, directly or indirectly. The herbicide regarded as most useful against submerged aquatics is sodium arsenite. Copper sulfate is recommended for control of filamentous or other objectionable algae.

Information on control of marshland weeds is limited but growing. Effective water-level management is often the best means of replacing undesirable plants by good ones. In particular, summer drawdown of water has been found a very practical means of improving waterfowl habitat. At the station where I work, this method quickly changed two comparatively barren ponds into popular havens for ducks and geese. It has been found, however, that the drawdown may have to be omitted in alternate years to prevent infestation by weeds.

Control of each kind of marsh weed is a special problem requiring detailed study of methods and materials and discovery of the most vulnerable stage of growth. In each instance, the main objective is not killing weeds but replacing them by useful plants. Procedures in this field can be regarded as satisfactory only if they conform in: economic feasibility, control of sufficient duration to justify efforts, and rapid replacement by desirable plants.

Chemicals useful in this field are largely the standard ones applied to upland weeds. 2,4-D is used most extensively but Ammate and TCA have been found effective on some species. Mechanical means of control have much value under certain conditions; mowing devices accomplished what may be regarded as the greatest single victory in the war on wetland weeds - nearly complete eradication of the so-called waterchestnut on the Potomac River.

Alert watchfulness to prevent invading weeds from becoming well established can sometimes save many dollars and headaches. Consider the millions that could have been saved if water-hyacinth, waterchestnut, saltcedar, and similar invading pests had been nipped in the bud. Probably the best time to win a weed war or any other kind of battle is before it starts.

"WEED CONTROL INVESTIGATIONS ON SOME IMPORTANT AQUATIC PLANTS WHICH IMPEDE FLOW OF WESTERN IRRIGATION WATERS"

Eugene T. Oborn
U.S.D.A. and U.S.D.I.
Denver, Colorado

Abstract

In order to meet the constantly growing demand for increased food and fiber production in this country, it has been necessary to place more land acreage under irrigation by impounding river waters and establishing irrigation canal distribution systems. In some instances, within a few months obstructing aquatic plant growths become established in and along the newly established irrigation waterways, making it necessary to apply various types of weed control measures in order that originally designed carrying capacities of the canals might be maintained. Methods involving new techniques are suggested which offer a solution to the problem at hand with eradication or control being brought about with an expenditure of minimum time, effort and cost.

Needle spike rush and dwarf arrowhead growing in the presence of direct sunlight are water-submersed, low-growing, mat-forming plants. In the absence of direct sunlight these plants assume a more rank habit of growth. One or both of these plants might be planted in irrigation ditches or lake bottoms to facilitate the holding of shifting silt and prevent growth of the ranker growing pondweeds.

Both the chlorinated and methylated benzenes are effective aromatic solvent herbicides. In general, when using these chemicals, regrowth was approximately twice as rapid for undrained treated tanks as it was for those drained before treatment.

Applications of 2,4-D at rates varying with the normally submersed species predominating can effectively kill underground water plant propagules with concentrations in general varying between 5 and 15 pounds to the acre.

Ten months following placement of pellets on the soil bottom of tanks in which rooted aquatic

plants were growing, most of the submersed aquatic plants tested were killed with CMU concentrations of less than 10 ppm. The 2,4-D in concentrations between 75 and 150 ppm cleared tanks of initial vascular plant growth but permitted replacement by pond scum.

Harvested submersed aquatic weeds may be used to advantage as green manure to fertilize nearby farm lands and thereby defray part of the cost of weed removal from irrigation waterways.

Domestic animal grazing has proven to be an effective method of controlling broad-leaved cattail infestation when they interfere with normal agricultural practices. The low point in naturally occurring seasonal carbohydrate food reserves varies not only with the species of cattail involved but with the growth habitat as well.

Cattail starch grains were readily used up even when the lower concentrations of 2,4-D were applied.

Applications of 2,4-D can effectively kill underground emergent water plant propagules with concentrations varying between 3.0 pounds per acre for water cress and 35.5 pounds per acre for ripgut grass.

All emergent aquatic plants tested including water cress, parrot's feather, and water hyacinth were killed with CMU concentrations between 15 and 19 ppm. Apparently CMU is a compound which will kill waterweeds at concentrations safe for animal aquatic life, including fish.

The initial 5 minutes of wash waters traversing herbicidal field treated areas should be wasted to avoid crop injury.

In both the predominantly submersed and emergent treated aquatic plants, radioactive 2,4-D readily passed the water line and also accumulated in the roots.

In instances where thallophytes came in contact with concrete mortar specimens having percent SO_3 in mortar of 0.6 or higher, pitting after 5 years of contact and 50 cycles of freezing and thawing was very pronounced. Pitting of the mortar surface was much less when SO_3 percent was about 0.2.

CONTROL OF SUBMERSED WATERWEEDS IN IRRIGATION CANALS

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Abstract

The encroachment of submersed water weeds plants into irrigation systems presents a major problem to irrigation water users. In recent years considerable research has been initiated to provide more economical means of control of these costly nuisances. One of the outstanding developments of this research is the use of aromatic solvents for control of submersed pondweeds in irrigation ditches.

Aromatic solvents, as here referred to, include aromatic hydrocarbons of the following specifications: distillation range 280°F to 420°F with about 80% of the material distilling between 290 and 390°F and an aromatic content of 85% or more. Most of the aromatic solvents used for waterweed control are of petroleum origin. However, those of coal tar origin are equally effective.

The first tests of these materials for waterweed control were made cooperatively by the Bureau of Plant Industry, U.S.D.A., and Bureau of Reclamation, U.S.D.I., in 1947. Extensive experimental tests have been conducted at field stations and on various irrigation projects throughout the western states during the past 5 years. Rates of 5.5 to 10 gallons of aromatic solvent per cubic foot per second flow of water have been found to control different species of submersed waterweeds under various conditions.

A dilute emulsion is created in the irrigation water by spraying aromatic solvent and emulsifier beneath the surface with conventional weed spray equipment.

This emulsion passes through the irrigation channel and is absorbed by the waterweeds causing a contact type of kill. Treated plants become limp and sink toward the bottom of the channel and the capacity of the ditch is greatly restored usually within 24 to 48 hours. The dead plant tissue is worn away by the water and does not become a clogging problem.

After considerable study of the relationship between amount of aromatic solvent and length of application period, it was determined that the recommended rates of 5.5 to 10 gallons per c.f.s. be applied in a 30 minute period. Thus, in treating a ditch the entire amount of aromatic solvent should be injected in 30 minutes.

A variation in recommended rate of treatment is necessary because of the difference in response of the different species to aromatic solvents. Horned pondweed (Zannichellia palustris L.), waterweed (Anacharis Canadensis (Mech.) Planchon) and Leafy pondweed (Potamogeton foliosis) are controlled by 5.5 to 6 gallons per c.f.s. A rate of eight gallons per c.f.s. is needed for control of the more resistant sago pondweed (Potamogeton pectinatus L.), and ten gallons of solvent per c.f.s. is necessary for control of Richardson's pondweed (P. Richardsonii Rydb.), American pondweed (P. Nodosus, Pairet) and water stargrass (Heleranthera dubia Maom). The above rates of treatment are effective for 3/4 mile up to three miles or more depending on plant density, water velocity and other conditions of the treatment. These treatments are most effective if applied soon after plants have begun vigorous growth and as soon as there is a noticeable hinderance to water flow.

Effect on crop plants. Irrigation of several crops with water containing aromatic solvents at rates necessary for control of waterweeds caused no significant reduction in yield. Crops tested included alfalfa, beans, carrots, cotton, grain sorghum, ladino clover, lettuce, lima beans, oats, orchard grass, potatoes, sugar beets and sweet corn.

Effect on animal life. Aromatic solvent as used for waterweed control in irrigation channels is lethal to fish, crayfish, snails and many types of insects that are found in the water. Guinea pigs

were not harmed by consumption of aromatic solvent treated water at the recommended rates for waterweed control and no cases of injury to livestock from actual field treatments are known.

Control of algae. Copper sulfate has given variable results in control of waterweeds in irrigation systems. Concentrations 1 to 5 parts per million maintained for about 30 minutes have given good control of algae in some ditches. High alkalinity of much of the irrigation water limits the effectiveness of the copper sulfate.

Rosine Amine D Acetate. Recently another chemical, Rosine Amine D Acetate (Rada), was found to be highly toxic to algae. A few tests have shown a concentration of 10 to 20 ppm maintained for 15 to 20 minutes to give good control of algae. Further field testing is needed to establish the best means and limits of using Rada for control of algae and other submersed waterweeds.

CONTROL OF EMERGENT AQUATIC WEEDS IN IRRIGATION CANALS

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Abstract

Emergent aquatic weeds are an important problem on irrigation systems in 17 western states. They reduce capacity and rate of water flow in canals, increase seepage losses, and cause heavy losses of water through transpiration.

Cattails (Typha spp.) are the most important and widespread of the emergent aquatic weeds. Others which are important in certain sections are: the bulrushes (Scirpus spp.), the sedges (Carex spp.), parrot's feather (Myriophyllum spp.), watercress (Nasturtium officianale), and marsh smartweed (Polygonum spp.).

There has been much improvement in the methods of controlling some of the aquatic weeds during the past five years. However, little research work has been done on the sedges or smartweed and no really satisfactory methods of controlling them are known. Parrot's feather and watercress have been successfully controlled with 2,4-D in oil-water emulsions after the original infestation was removed mechanically. Narrowlead cattail (Typha angustifolia) which predominates in the Southwestern states, is being successfully controlled by spraying at the preheading stage with 400-600 gallons per acre of water, containing 1.5 pounds of 2,4-D, 8-10 pounds of sodium TCA, and 3/4 - 1 pint of a spreader-sticker per 100 gallons. This method has proved much less effective on broadlead cattail (T.latifolia) which predominates in the northern two-thirds of the region.

Experiments conducted at Logan, Utah, during 1949 to 1953, have revealed several effective methods of controlling broadleaf cattail. Cutting below the waterline, trampling below the waterline, and spraying with 160 gallons per acre of aromatic weed oil three times during the season at preheading stages each reduced cattail 80 to 90 percent in one year. Applying these treatments twice during the season, beginning at the heading stage was nearly as effective in one experiment but much less effective than three applications in another experiment.

Spraying with 2,4-D or 2,4,5-T alone at rates of 3 to 6 pounds per acre in either amine or ester forms was ineffective. Adding ammonium sulfamate or sodium TCA at 20 to 40 pounds per acre with a spreader-sticker to an amine or sodium salt of 2,4-D resulted in fair to good kills of cattail. However, best results were obtained by using a low volatile ester of 2,4-D and ten gallons per acre of diesel oil in 200 gallons total spray solution.

In experiments comparing amine and low valatile ester forms of 2,4-D at rates of 4, 6, 8, and 12 pounds per acre in combination with ten gallons per acre of diesel oil in 200 gallons of total spray solution, the ester consistently gave much better results at equivalent rates. The ester at four pounds per acre gave good results but there was some advantage for higher rates up to eight pounds per acre.

Low volumes of 20 or 80 gallons per acre were ineffective regardless of the amount of 2,4-D applied. The minimum effective volume was 160 gallons per acre and the optimum volume was 200 to 240 gallons per acre.

Two spray applications per season at preheading stages of growth were necessary for satisfactory control and were much more effective than one application at the heading stage.

Usually, the stands of cattail were reduced 90 percent or more by two applications the first year and were eliminated or nearly so by the third spray treatment, which was applied in the spring of the second year.

Exploratory experiments with soil sterilant herbicides including sodium chlorate, borates and borate-chlorate mixtures, sodium TCA, and CMU showed them to be mostly ineffective on cattail.

USE OF RADIOACTIVE ISOTOPES OF 2,4-D IN BRUSH CONTROL

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Abstract

Autographs of bark, shoot tips, and leaves of brush species treated with radioactive 2,4-D indicate that movement of this indicator parallels that of foods in these plants. Depending upon physiological activity movement from a treated leaf may be downward to the roots, upward to growing shoot tips, or in both directions.

Correlating the isotope work with Dr. Leonard's many spray tests it seems evident that to obtain successful treatment of brushy species by the spray method it is necessary (1) that the herbicide be absorbed; (2) that photosynthesis be active to provide assimilates for movement in the phloem; (3) that translocation from active leaves to an

active sink in the roots be going on and (4) that root activity involves meristematic activity and not merely storage.

Because brush species grow in mixed stands that contain both deciduous and evergreen species that blossom and vegetate at different times of the year there can be no optimum time or condition for treating such populations.

CONTROL OF WOODY PLANTS WITH CHEMICALS ON RANGE AND PASTURELAND IN THE SOUTH

A. H. Walker
Texas A and M. College System
College Station, Texas

Abstract

Nearly half of the brush infested land in the United States, or over 108 million acres are in the fourteen southern states. These woody plants take at least a third of a billion dollars annually out of the pockets of livestock producers. This brush takes water and minerals which should be used by forage growth for livestock production. Some brush controlled areas have produced five times as much grass as untreated ones the next year even under drouth conditions. Average production increase following woody plant control usually varies from 20-50%, depending upon rainfall, site, plant cover and range management. This means more pounds of meat per acre and efficient production, which is paramount right now.

Chemical control of woody plants offers more promise than any other one method. Research workers have attempted to develop effective treatments, the cost of these and possible return and range management practices necessary for continued benefits. This management following brush control will largely determine the success of the program.

The most common chemicals used in brush control work are 2,4-D, 2,4,5-T and Ammate. These chemicals may be applied by broadcast methods and individual tree treatment. Sand sage brush, mesquite, post and blackjack oak have been successfully controlled by aerial application. Individual tree treatment using Ammate or 2,4,5-T to control sprouting may be applied to the stumps, trunk base, in cups or in frills.

Extension has played a large part in expanding chemical control of hardwoods. Demonstrations, meetings, news articles and circulars have been used on a wide scale.

The wide variety of woody plants in the South which require different chemicals and formulations for control is a definite limitation. Also much research is needed on the control on some species in line with probable returns. Brush control is only a part of range or pasture management and must be combined with other practices for continued benefits. Present research, however, indicates that chemical woody plant control will return high dividends on the investment.

CONTROL OF WOODY PLANTS USING "AMMATE" WEED AND BRUSH KILLER AND OTHER NON-GROWTH REGULATOR HERBICIDES

Arne E. Carlson
E. I. duPont deNemours and Company
Wilmington, Delaware

Abstract

Economical control of woody plants through the use of herbicides has found broad acceptance for industrial application. Maintenance programs are depending more and more on chemicals to provide more desirable rights of way.

There are probably few if any herbicides in use today which having shown promise for control of weeds have not been evaluated for their effect on woody plants. It is hardly practical to review all of the products tested for purposes of woody plant control but rather to briefly summarize the manner in which the effective ones are used. In another presentation of this same panel on woody plant control the application of 2,4-D and 2,4,5-T products is reviewed.

"Ammate" Weed and Brush Killer (based on ammonium sulfamate) is specific for control of woody plants and has been accepted broadly as an effective herbicide for brush control. It is a general purpose brush killer, being relatively non-selective and therefore very effective in controlling mixed species of brush. "Ammate" when used as foliage spray is more nearly a "one shot" treatment than any of the other commonly used products, making retreatment unnecessary for several years. When properly applied it will kill practically all species of brush to the ground, including oaks and other difficult to control species, and 80% or better inhibition of resprouting can be expected. Sprouts which do occur are usually materially affected, and growth may be inhibited for several years during which time many of them will die.

"Ammate" is usually applied as a foliage spray using 75 pounds per 100 gallons of water. Thorough wetting of foliage and stems is as important when using "Ammate" as it is when using 2,4-D - 2,4,5,-T products. The use of about 4 ounces of Spreader-Sticker with each 100 gallons of spray solution is essential to assist in obtaining thorough wetting.

"Ammate" is also used as a stump treatment at the time of cutting to reduce sprouting. The dry crystals may be used at the rate of 2 ounces per 6 inches diameter or the stump may be thoroughly wet with a concentrated solution containing 4 to 6 pounds per gallon of water.

"Ammate" is non-volatile and when used with reasonable care, the spray will not drift in sufficient amounts to injure crops or ornamentals growing adjacent to the treated area. It will kill those plants which are thoroughly wet with the spray solution but an occasional drop on a tomato, grape or cotton, for example, will not injure that plant. Although it is relatively non-selective for control of woody plant, it does not leave the soil unproductive. Herbaceous weeds and grasses flourish once the woody plant canopy has been removed. Perennial broadleaved and grass plants may suffer a top

burn, comparable to that caused by fire, at time of foliage application to the woody plants. It may look like the scorched earth for a short period of time but regrowth from the roots occurs quickly.

"Ammate" is somewhat corrosive to certain metals but it is not as serious as is generally believed. Brass is particularly susceptible to season cracking and brass spray guns should be replaced with stainless steel in equipment when "Ammate" is used. Other steel or iron parts exposed to "Ammate" spray solutions have been effectively protected using cheap oil at regular intervals to coat these areas.

The soil sterilant type of herbicides such as arsenicals, chlorates and borates have not found broad acceptance to date as woody plant control agents due principally to inherent qualities of toxicity, fire hazard, or bulk quantities necessary to effect control. Combination products such as borate-chlorates are used to some extent as spot treatment for control of poison ivy and poison oak on industrial sites.

One other product which deserves mention in this group is CMU Weed Killer. Its principle application to date has been for control of broad-leaved weeds and grasses in industrial areas where it is desirable to control all vegetation.

During the past two years it has also been tested rather extensively for control of woody plants. Evidence to date indicates that the application may be similar to the basal stem method except that the material will be applied to the ground around each stem. The results look quite promising and certainly merits further testing.

SOME ASPECTS OF RIGHT-OF-WAY CONTROL WITH 2,4,5-T AND 2,4-D

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Abstract

Foliage spraying is the most common method of chemically controlling woody plants on right-of-ways. Important factors determining success of these sprays include thorough wetting of all stems and coverage on all sides of the plant.

Spray mixtures are generally made up with a gallon of low volatile esters (containing two pounds each of 2,4-D and 2,4,5-T) in 100 gallons of spray. The trend in areas where such hardwoods as ash, oak, and maple predominate is toward the use of 2,4,5-T esters alone at three pounds acid equivalent per 100 gallons of spray.

In setting up a spray program and in reporting results, it is important to identify the species beyond the genus. This is important since all species of a genus do not respond in the same manner. An example of this is the willows, of which there are many susceptible species. However, there are also some species which are quite tolerant and it is misleading to classify all willows as sensitive.

Foliage sprays should be applied after the first flush of growth in the spring. Satisfactory results may be anticipated from that time up to the time that the leaves begin to lose their vigor in the fall. In experiments reported with this paper, 2,4,5-T has given satisfactory results on northern pin oak and white oak even after red pigments had begun to develop in the leaves. The addition of small amounts of oil to the spray mix did not materially aid in obtaining greater kill. Ten gallons of oil applied with 2,4,5-T in 90 gallons of water to plants in this stage seemed to improve stem kill somewhat. However 20 gallons of oil added to the spray mixture increased root sprouting the first year after application. These late season results with 2,4,5-T may only be anticipated on oak, since little data is available on the reaction of other species to this type of treatment.

Basal and stump treatments, using not less than 16 pounds acid equivalent of 2,4,5-T esters in 100 gallons of straight oil spray have given satisfactory control. The key to success in treatments of this type is to thoroughly drench all exposed areas of the stump or stems at the ground line. All sides of the stems must be wet and the oil should run down the stem or stump in copious amounts. Treatment of stumps under two inches in diameter has often given erratic results, particularly on such species and willows. The stump or basal treatments are probably the most effective methods of treating such resistant species as oak, maple and ash. However, they have not always been successful in suppressing lateral sprouts of such species as sumac.

NEW DEVELOPMENTS IN BRUSH CONTROL

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Abstract

There are many new techniques, methods of application and formulations in the field of brush control research. Much of the new work is concerned with the determination of the physiological action of herbicides as such knowledge is necessary for a better use of herbicides in solving our brush problems.

Items which can be included under techniques include the use of nursery stock to screen treatments and chemicals and the tagging and maintaining of life histories of individual trees in field plots. The study of nursery stock plants as used by Dr. Coulter presents an advantage of providing for application of treatments to desired species, of uniform size and morphological characteristics. Such nursery studies could conceivably allow control of certain growth conditions. Also valuable is the individual tagging of trees in field plots and the keeping of life histories of such trees from the time of treatment. It is conceivable that such knowledge would be of aid in arriving at conclusions for field plot applications.

One of the requirements for intelligent research on the use of herbicides is a knowledge of the actions of the chemical inside the plant. Translocation is one of the most important of

these and is being studied by many research workers. Dr. C. E. Fisher and his aides at the Spur, Texas, Experiment Station have included a study of this problem in their work on mesquite control. They have devised a gall-like wrapping of cotton with an oil and waterproof covering. The chemical is applied in this gall and its upward and downward movement, if any, is observed. Thus far, they have found little or no downward movement. As a result, their present recommendation for basal applications stipulates that a one percent solution of 2,4,5-T ester in diesel oil be applied in sufficient quantity and low enough to give physical contact to the sprouting zone.

In another study of this nature Drs. Crafts, Stewart and Leonard are using radio-isotopes as tracers with 2,4-D to follow its movement in the stem of the plant. Their work on woody plants has indicated a downward movement in the bark of certain species in the winter season which could be the reason for the success of dormant sprays on these species.

A probe type applicator is a new technique and method of application reported by McCully at College Station, Texas. They have had good results using a probe to place the herbicide about four inches below the soil surface and adjacent to the primary axis. Along with the probe they have redesigned a knapsack sprayer to include a metering jar to aid in controlling more closely the volume of solution they apply in each treatment. Results of this work show good kills on post and blackjack oaks of six-inch or less stem diameter with complete kills resulting from certain treatments of low volatile esters of 2,4-D or 2,4,5-T in oil applied during the period of leaf expansion. Their studies indicate the amount of herbicide is apparently more important than the concentration of the solution.

Herbicides reported this year include few that are entirely new in the research field but do include many attempts to make new use of the older known materials. CMU is being studied and reported in many new trials on oaks, mesquite and other species.

Dr. Leonard is using undiluted 2,4-D and 2,4,5-T applications to ax cuts with good results. Two ml. of undiluted 2,4-D herbicide per ax cut has shown good results on Digger Pine, Interior Live Oak and Blue Oak in winter and spring applications. The type of cut appears to be important in that shallow cuts may give poor kills and, on the other hand, it is indicated that the cut should not go into the heart wood.

This report is of only a few of the new developments in this field but serves to indicate the high level of interest which should give us the answers to many of our brush control problems.

THE IMPORTANCE OF BRUSH CONTROL TO REA BORROWERS

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Abstract

At the close of 1953 approximately 1,290,000 miles of REA-financed electric power lines are in service. It is estimated that of this mileage approximately 375,000 acres were cleared originally by cutting and removal of the brush. Subsequent reclearing has been necessary to adequately maintain most of this right-of-way. The money required for this one activity is often the major item of maintenance. After the purchase of electrical energy, right-of-way maintenance may require the next largest expenditure for a mature electric system.

Reports from REA borrowers using herbicides for brush control almost always indicate substantial savings in clearing costs. Where a foliage application has been substituted, the savings may range up to 85 percent of the cost of cutting.

In 1952 a questionnaire circulated among all borrowers indicated that in that year 229 used foliage spraying; 107 used stump spraying; and 71 used basal spraying. A study of the year-by-year increases in the number of users of these chemical methods indicate about 20 percent increase over those figures for 1953. Over 30 percent of all borrowers are using chemicals in their brush control operations.

WEED CONTROL IN ONIONS IN THE ORGANIC SOILS OF THE FLORIDA EVERGLADES

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Abstract

Trials at the Everglades Experiment Station have shown that onions may be successfully grown in this area. The rich organic soil and the relatively long growing season of the crop presents, however, a tremendous problem in regard to the control of weeds. This study was undertaken to investigate the possibilities of weed control using herbicides as both pre and post-emergence treatments and determining their effects on yields.

Three experiments were conducted on a mature Everglades peat soil having a pH of 5.5, using the Texas Early Grano variety. The treatments on a per acre basis were as follows:

Pre-emergence experiment--Chloro IPC 10 and 12 pounds, 2,4-D amine salt 1 and 2 pounds, Oktone 2.5 and 5.0 pounds in diesel oil, DNOSBP 1.5 and 3.0 pounds, NIX plus wetting agent 10 and 12 pounds, Diesel oil 30 and 60 gallons, Stoddard solvent 30 and 60 gallons, and check cultivated and uncultivated; post-emergence experiment No. 1.-2.5 percent sulphuric acid, KCNO 12 pounds, NIX 10.0 pounds, and a hand cultivated and weeded check; post emergence experiment No. 2.-2.5 percent sulphuric acid, KCNO 12 pounds, NIX 10 pounds, Sinox W.O.75, Chloro IPC 8 pounds, CMU 2 pounds, Endothal 3003.6 pounds, Chloro IPC 4.0 pounds plus KCNO 10 pounds, and a cultivated check. For the pre-emergence experiment three depths of planting were used and the ground was packed by the use of a heavy roller before the treatments were applied. After the residual effect of the herbicides disappeared from the ground hand weeding was employed. The number of hand weedings varied

from one to three depending on the residual effect of the chemical used. The first post-emergence treatments were applied, on the average, 43 days from seeding as foliage sprays. The second and third post-emergence treatments were spot treatments on the weeds. One hand weeding was necessary a month after the last post-emergence application.

In the pre-emergence experiment there was a significant reduction in yield in the highest concentration of the chemical treatments when compared with the cultivated check. The reduction in yields is in part attributed to the reduction in stand of the onion plants due to chemical treatments. 2,4-D and Chloro IPC significantly reduced the stand of the onions. Best stand for Chloro IPC and 2,4-D was obtained at 1 inch depth. Onion plants were tolerant to the concentrations of Chloro IPC used, and this chemical gave an excellent control of weeds, for over three months; furthermore, only one hand weeding was required until harvest. The next best chemical was 2,4-D with a residual toxicity of 2 months, but two hand weedings were necessary. All the other treatments received three hand cultivations. Stoddard solvent was the least effective in controlling weeds, followed closely by the diesel oil treatment. Oktone suppressed weeds fairly well, but its effect disappeared rapidly and it reduced stands more than Chloro IPC and 2,4-D. The effect of NIX on weeds was intermediate between that of Oktone and diesel oil. KNOXBP was too toxic for the onion plants at the concentration used.

In the post-emergence experiments foliar application of the herbicides in all cases produced temporary burning of the leaves of the onion plants. Yields of the chemically treated plants were significantly reduced. In the second post-emergence experiment yields from the CMU and sulphuric acid plots were significantly greater than from the rest of the chemically treated plots, although significantly less than the check. The control of weeds was excellent with CMU, good with sulphuric acid, NIX, KCNO, Endothal 3003 and the mixture of Chloro IPC and KCNO.

Storage of the onion bulbs for about one and a half months failed to show any differences in storage quality due to treatments.

PROMISING HERBICIDAL METHODS FOR THE CONTROL OF ANNUAL WEEDS IN SEED ONIONS

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Abstract

Weeds in onions which are flowering or maturing seed may reduce yields considerably, and yet they are almost impossible to remove by mechanical means, without even greater injury to the crop. Since 1949 experiments have been under way in Utah to find feasible herbicidal methods of controlling annual weeds in seed onions. The experiments were conducted with Sweet Spanish variety, except in 1953 when the White Portugal was used. Other experiments conducted simultaneously, but primarily for other objectives, have shown that where seed onions can be grown with infrequent surface irrigation, or we

surface irrigation, or where irrigation is frequent, but rows are as close as 9 inches apart, weed growth is often greatly reduced.

In each of the herbicide experiments, one series of treatments was made between the onion rows after bolting had begun and immediately after the final cultivation. The sprays were applied to cover the entire soil surface but to contact only the basal two or three inches of the onion plants. In 1952 and 1953, the treatments were made in duplicate series and then one series was immediately given an artificial rain (overhead irrigation) equivalent to a moderate precipitation. Beginning in 1951, a group of chemical treatments applied immediately after the onion bulbs were planted in early spring was added to each experiment.

A spray application of three pounds per acre of 2,4-D acid as a wettable powder when the onions were beginning to bolt was the most promising treatment tested. This treatment gave excellent season-long control of annual broadleaf weeds and weedy grasses and resulted in yields of onion seed equal to or greater than those of untreated hand-weeded check in all experiments where moderate rainfall (.50 to 1.25 inches), either natural or artificial, was received or applied soon after chemical applications. When 2,4-D acid was applied in early spring immediately after the onion bulbs were planted, good weed control but severe injury to onions resulted.

In 1952 and 1953, experiments with 2,4-D ethyl sulfate gave results similar to those from 2,4-D acid at equivalent rates when applied as the onions were beginning to bolt in early June.

CMU (3-p-chlorophenyl-1,1-dimethylurea) was tested in the 1951, 1952 and 1953 experiments, immediately after the bulbs were planted and also at bolting stage. In every instance, CMU at two pounds per acre gave better weed control than any other chemical treatment tested. CMU at one or two pounds per acre caused no reduction in onion seed yields either from early April or early June applications in 1951 and 1952. In 1953, however, the rates of two and three pounds per acre reduced onion seed yields considerably when applied at either stage of growth. This reduction in yield caused by CMU in 1953 may have been due to either or both the difference in variety, or the above-normal precipitation in early spring of 1953.

Like 2,4-D acid, CMU gave good weed control and onion yield results only when moderate rainfall, either natural or artificial, occurred soon after the treatments. When surface irrigation only was given, weed control was unsatisfactory and onions were likely to be injured. Unlike 2,4-D acid, CMU applied immediately after onion bulbs were planted in early spring did not injure the onions except where the rate of application was excessive (2 pounds per acre) or the rainfall subsequently received was unusually heavy. CMU at one pound per acre did not injure onions in any of the experiments but gave only partial weed control in most instances.

Sodium pentachlorophenate and 3-chloro IPC were tested in several of the experiments. Neither

chemical gave as good results as did CMU or 2,4-D acid under favorable conditions.

STUDIES ON CHEMICAL WEED CONTROL FOR MUCKLAND ONIONS

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Abstract

This paper is a report on onion weed control studies carried on during the years 1951-1953.

Since 1951, when CMU was first introduced as a herbicide it has been included at several rates in screening tests to determine its value for pre- and post-emergence weed control in onions. The results, in terms of weed control and onion yields, obtained by the pre-emergence application of CMU and two of the older herbicides, Stoddard solvent and potassium cyanate, in these tests indicate that CMU at two pounds per acre is considerably more effective than either Stoddard solvent or potassium cyanate in controlling weeds on muck soils.

Pre-emergence studies conducted in 1952 and 1953 to determine if the toxicity of CMU to weeds and onions is affected by time of application showed that weed control is better when weeds are allowed to emerge before CMU is applied. However, if onions were allowed to emerge before CMU was applied, injury to onions occurred when heavy rains fell within three days of application.

Post-emergence studies have shown that CMU has selective toxicity for weeds in onions. Studies to determine at which stages of growth, if any, onions are most susceptible to injury from CMU, showed that CMU is slightly more toxic to onions in the loop or one-leaf stage than to onions which are bulbing. CMU applied repeatedly to onions as complete coverage sprays resulted in reduced yields while similar sprays applied basally did not reduce yields of onions.

In 1953, a factorial experiment was conducted on four muck farms in southern Minnesota in which CMU was compared with weedicide treatments recommended by the North Central Conference for pre-emergence, early post-emergence, and lay-by weed control. Three pre-emergence treatments (untreated, 80 gallons Stoddard solvent, and 2 pounds CMU), three early post-emergence treatments (untreated, 12 pound KOCN, and 2 pounds CMU), and three lay-by treatments (untreated, 1.875 pounds DNBP, and 2 pounds CMU) were applied in all possible combinations to duplicate plots on each farm. At each stage of growth CMU gave considerably greater weed control than the other herbicides used. However, in these tests, CMU also significantly reduced onion yields when applied either pre-emergence or early post-emergence but not when applied as a lay-by treatment. In addition, onion yields were further reduced when CMU was applied as an early post-emergence treatment to onions which had been sprayed with CMU pre-emergence.

In summary, CMU has consistently given better weed control in onions than other herbicides when used as a pre-emergence, early post-emergence, or lay-by treatment. In most studies carried on at the University of Minnesota, it has not been any more toxic to muck-grown onions than other weedicides which are now recommended for weed control in this crop. Apparently, however, under certain environmental conditions onions are either predisposed to injury by CMU or are inhibited in growth so much during the period following herbicide treatment that they do not recover from the setback caused by the herbicide treatment. Just what these conditions are is unknown. Under such conditions, two pounds of CMU applied either as a pre-emergence spray or as an early post-emergence spray may reduce yields by 20 to 25 percent. If both applications are made, yields may be reduced by as much as 40 percent. Lay-by treatments using two pounds of CMU have been effective in controlling purslane and other annual weeds until harvest and have not affected onion yields.

CHEMICAL CONTROL OF PURSLANE IN MUCK-GROWN ONIONS

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Abstract

A number of chemicals were used in screening tests for the control of purslane in onions: CMU, Chloro IPC, Dow General, NIX, sodium pentachlorophenate, Dow Selective, potassium cyanate, potassium cyanate plus sticker, Agronyl A, Endothal, Sulfasan, mono-sodium cyanamid, Alanap-1, Alanap-2, Alanap-5, Crag Herbicide 1, sodium arsenite, calcium cyanamid dust, Sesin, Esso 45, Esso 180, and Esso Medium Heat. Of these 7 were chosen for intensive study: CMU, Chloro IPC, Alanap-1, Alanap 5, Sesin, Crag Herbicide 1, and Endothal. These were studied in a series of field experiments, both pre-emergence and post-emergence. The pre-emergence experiments indicated that Crag Herbicide 1, Sesin, and Endothal were unsafe to use at that time. None of the chemicals caused reduced yields in the post-emergence experiments at the rates used. Both Alanap-1 and Alanap-5, however, caused severe twisting of the onions in both the pre-emergence and the post-emergence work; and CMU caused a yellowing of the plants and die-back at the tips of the leaves whenever used at rates above 1 pound in the post-emergence experiments. Chloro-IPC was the only chemical that caused no reduction in yield or visual symptoms of damage to the onions regardless of time or rate of application. This chemical also gave better control of purslane and greater residual control, even at rates as low as 4 pounds per acre, than any other chemical. Residual control for more than 3 weeks was obtained with 2 pounds of this chemical, and for more than 3 months with 8 pounds. As much as 16 pounds per acre were used as both pre-emergence and post-emergence sprays without damage to the plants. Large-scale commercial trials of this chemical, all at 6 pounds per acre in 100 gallons of water, have now indicated that it is effective against purslane over a wide range of environmental conditions. No damage to onions was obtained regardless of methods of application.

FIVE YEAR'S RESEARCH ON WEED CONTROL IN INDIANA ONIONS

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Abstract

Several replicated experiments have been conducted on muck soil each year for the past five seasons. Most of the trials were with the Early Yellow Globe variety but Sweet Spanish was used in a few cases. Records taken include onion stand and yield and weed counts by species or, in a few experiments, time required for hand weeding. During the course of this work it has become obvious that a sequence of herbicide treatments throughout the season will be necessary to obtain the maximum reduction in hand weeding required. This is necessary because of the many different weed species commonly present in onion fields which have different periods of peak germination and to the fact that onions never shade the ground sufficiently to suppress weed growth. The results of these experiments will therefore be discussed by time and method of application.

Pre-emergence treatments. Several herbicides have given good contact kill of weeds that emerged before the onions without causing damage to the crop; these include Stoddard solvent at 75 gallons per acre, sodium isopropyl xanthate at 12 pounds, potassium cyanate at 20 pounds and 5% sulfuric acid at 100 gallons. A few materials that have a residual effect have given good control of certain weed species without injury to onions planted at least one inch deep. CIPC has been highly effective against smartweed and wild buckwheat (Polygonum spp.) and purslane (Portulaca oleracea) at the rate of 8 pounds per acre yet has no damaged onions at rates up to 12 pounds. Control of pigweed (Amaranthus spp.) and lamb's quarter (Chenopodium album) has been fair to poor. The amine salts of 2,4-D have not injured onions planted at least one inch deep when applied at rates of $\frac{1}{2}$ to 1 pound per acre just before emergence, except on recently cleared, raw peat soils. Since 2,4-D gives good control of pigweed and lamb's quarters but poor control of smartweeds, a combination treatment of $\frac{1}{2}$ pound of 2,4-D and 8 pounds of CIPC has resulted in the best all-around weed control of any treatment yet tested. Combinations of CIPC with some of the contact type herbicides mentioned above have also been highly effective in certain weed situations.

A limited number of experiments with CMU have shown no onion injury at rates up to 2 pounds but some stunting at 4 pounds per acre. Control of pigweed, lamb's quarters and purslane has varied from poor to good at the two-pound rate while smartweeds have been highly resistant to this herbicide on muck soil.

Herbicides that have caused severe onion injury in one or more experiments include 2 pounds per acre of endothal, $4\frac{1}{2}$ pounds of TCA and the esters of 2,4-D. N-1 naphthyl phthalamic acid at rates up to 12 pounds per acre and calcium cyanamide dust at 100 to 400 pounds caused no onion injury but were not consistently effective on enough weed species to be worthwhile.

Early post-emergence treatments. From emergence until the onions have about two true leaves, the only reasonably safe herbicides tested have been 2 to 3% sulfuric acid and 10 to 15% phosphoric acid at 100 gallons per acre or potassium cyanate at 10 to 12 pounds. Even these sprays sometimes caused injury to the onions making it necessary to vary the concentration with weather conditions and plant succulence. The onions appear most sensitive when in the "flag" stage and the Sweet Spanish variety was more subject to injury by acids at all stages of growth than Early Yellow Globe. Only certain weed species were controlled but results were generally best when spraying was done while the onions were in the "knee" or "crook" stage. At this time the weeds are small and more easily killed yet the onions are fairly resistant.

Directional post-emergence treatments. As soon as the onions have 2 to 3 true leaves it is possible to direct herbicidal sprays so that only the more resistant basal portion of the onion plant is contacted. It was found possible to use stronger treatments in this way than could be used earlier, thus controlling more weed species. Potassium cyanate at 16 to 20 pounds, sodium isopropyl xanthate at 12 pounds or 3 to 4% sulfuric acid at 100 gallons per acre have effectively controlled many mid-season weeds when applied in this way. Sulfuric acid was not safe, however, on the Sweet Spanish variety.

Post-emergence residual treatments. Certain herbicides with residual properties have controlled late germinating weeds when applied to onions in the 2 to 3 leaf stage or later. An application of 8 pounds per acre of CIPC has been outstanding in the control of certain weeds and in the lack of yield reductions. It has been especially effective against purslane. While most of the experimental applications were made directly over the tops of the onions, there may be some advantage in directing sprays of this material so that only the basal portion of the onion plant is contacted.

Less extensive trials have shown CMU to be promising as a post-emergence residual herbicide at rates somewhere between 1 and 3 pounds per acre. It gave better control of pigweed than did CIPC. In a single experiment in 1953, 4 pounds of TCA, 4 pounds of alpha alpha dichloropropionic acid and 8 pounds of the isopropyl ester of trichlorobenzoic acid did not reduce onion yields. These herbicides may prove to be valuable either alone or in combination with other materials since each is effective on specific weed species. Herbicides that have not been satisfactory for this purpose due to significant reductions in the yield of onions include sodium 2, 4-dichlorophenoxy ethyl sulfate (SES), N-1 naphthyl phthalamic acid, and N-1 naphthyl phthalimide.

Time required for hand weeding. Replicated experiments were conducted in which several different series of treatments were applied to onion plots and the time required for hand weeding throughout the season compared with that on control plots. In extremely weedy fields, the best series of treatments reduced the time required for hand weeding by over 50 per cent and was much more effective than any one application. There has been no reduction in yield of onions from a sequence made up of herbicidal treatments which individually were non-injurious.

Conclusions. Several herbicidal treatments have proven effective in reducing the amount of hand labor required for weeding onions but to obtain maximum effectiveness a series of treatments is necessary throughout the season. Due to the varability in weed population from farm to farm, no one sequence will be best for all locations. The choice of herbicides for each situation will depend on the weed species present and the time they normally germinate in a given locality, as well as the variety grown, weather conditions, relative cost and other factors.

A QUANTITATIVE STUDY OF THE COMPETITION OF WEEDS WITH VEGETABLE CROPS

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Abstract

Although several investigations have been made on the effects of weed competition on cereal crops, there is little work of this nature on row crops. At the University during the last two years, a study was made for the purpose of determining quantitatively some of the effects of weed competition on row crops. An effort was made to determine the amount of weed kill which is required to reduce to a minimum the injury caused by competition from weeds, as well as to determine the necessity of weed control in the early stages of growth.

All trials were conducted on an organic soil having a fairly consistent weed stand from year to year. Several species of weeds were present, but pigweed (Amaranthus retroflexus) predominated. All trials were completely randomized and replicated. In order to measure the effects of several degrees of weed competition, 15, 30 and 50 percent of the normal weed stand was allowed to compete with the crop for $3\frac{1}{2}$, $4\frac{1}{2}$, and $5\frac{1}{2}$ weeks after the emergence of the crop. The effects of these levels of competition on the crop were studied and compared to plots which received no competition. Measurements of injury to the crop were taken at the time that the competition was removed, and again at maturity.

After competition of a 15 percent weed stand for $3\frac{1}{2}$ weeks, the total weight of carrot plants showed a reduction of 30 percent; the diameter of the roots was reduced by nearly 15 percent. When 15 percent of the weeds remained for $5\frac{1}{2}$ weeks, the reduction in weight was nearly 55 percent, and in diameter 50 percent. The increase in injury during the interval from $3\frac{1}{2}$ to $4\frac{1}{2}$ weeks was greater than for any other comparable time. There was evidence of considerable recovery of the carrots between the time of weed removal and maturity. In fact, with the lower levels of competition recovery was complete in that it equalled the yield and diameter of the check which had been kept free of weeds throughout the season.

There was a tendency for the weight of weeds per plot to become constant as competition was increased. This indicates that on a given area of land, there is a maximum amount of plant growth that will be supported. It would be expected that at this point, competition would be at a maximum. The degree of injury to the crop was observed to level off as this maximum level of competition was approached.

Work is underway to study some of the basic factors which may be responsible for injury to crops under conditions of competition. The effect of weed competition on the leaf area and its effect on the amount of light which reaches the crop will be considered.

An instrument was developed by the Departments of Physics and Agronomy to measure directly the percentage of light which reached the level of the crop plants. It was found that the light which penetrated to the crop level at the high rates of competition was reduced by about 85 percent. It was noted that the decrease in light intensity was greatest between $3\frac{1}{2}$ and $4\frac{1}{2}$ weeks after emergence, which is consistent with the reductions in yield and diameter of the crop.

The area of the leaves of the crop plants was measured by means of an optical instrument devised with the co-operation of the Physics Department. It was found that the leaf area of the crop plants was reduced by 20 to 75 percent by the various levels of weed competition. As the leaf area may be considered as proportional to photosynthesis, it is not surprising that the weight and size of the crop plants were drastically reduced.

In addition to carrots, similar measurements were made on onions and beets to see if the same trends existed. Beets were found to respond similarly, but they had a somewhat greater ability to recover from initial injury than carrots. In onions, the injury resulting from low levels of competition early in the season was much more severe, and they were able to withstand much less total competition.

In summary, it was found that moderate levels of weed competition caused severe injury to several vegetable crops. There was some recovery however from initial injury after the competition was removed. There was considerable injury to the crop early in the season which emphasizes the importance of the timely removal of weeds. Light intensity at the level of the crop plants was reduced by as much as 85 percent at the higher levels of competition. These measurements at the various levels of competition were inversely proportional to the injury observed. It is suggested that light plays a major role in competition. Leaf area of the crop was severely reduced as a result of weed competition.

ACTIVITY AND FATE OF HERBICIDES IN SOILS

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Abstract

Studies were conducted on the fate and activity of herbicides in soils. The effects of temperature, amount of rainfall and soil type on breakdown and movement of 5 herbicides, 2,4-dichlorophenoxyacetic acid (2,4-D), trichloroacetic acid (TCA), N-1

naphthyl phthalamic acid (NPA), isopropyl N-(3-chlorophenyl) carbamate (CIPC), and 3-(p-chlorophenyl)-1, 1-dimethylurea (CMU), were studied. Additional experiments were conducted on the effect of exchange capacity and organic matter on NPA retention. Three distinct soils of Indiana were employed in the studies: (1) Princeton fine sand, (2) Delphi silt loam, and (3) a well-decomposed muck.

Constant temperature chambers maintained at 8°, 18°, 25°, and 35° C. were used for the breakdown experiments. Equivalents of 0, 2, 4, 8, 12, and 16 inches of rainfall were applied in leaching experiments. In a third study, soil columns were sliced and assayed for herbicidal activity at depths of 0, 1, 2, 4, 6, 8, and 10 inches after receiving 2 inches of rainfall. NPA, TCA, and CIPC were applied at the rate of 8 pounds per acre, while CMU and 2,4-D were applied at rates of 2 and 4 pounds per acre respectively. Results of a preliminary experiment indicated that it was necessary to double these rates for the temperature breakdown study in muck soil. Herbicidal activity was measured with a biological test using crabgrass as a test plant. In the case of NPA, a chemical test was also employed.

In general breakdown of these herbicides was found to be proportional to the temperature and the rate of breakdown increased progressively from the sandy soil to silt loam to muck. Herbicides varied in their resistence to breakdown. They could be listed in the following order of increasing resistance: (1) 2,4-D, (2) NPA, (3) CIPC, (4) TCA, and (5) CMU.

Leaching of herbicides was affected by an interaction of soil types and herbicides. TCA was observed to leach rapidly in all 3 soil types whereas 2,4-D leached readily in sandy and silt loam soils but was retained in an active form in the surface of muck. NPA movement was similar to that of 2,4-D except that some appeared to be retained in the soil surface to a greater extent than 2,4-D. CMU was very resistant to movement, and CIPC showed the least movement of the herbicides tried.

The capacity of muck to inactive CMU was indicated. When CMU was mixed with the muck soil at the standard rate (2 pounds per acre) inactivation was of such magnitude that crabgrass growth in the treated soil was equal to that of the control.

There was a highly significant correlation between retention of NPA by mineral soils and exchange capacity, and a smaller but still highly significant correlation of retention with organic matter content.

On the basis of these and other studies, explanations for variable field results are suggested, and applied implications are pointed out.

STUDIES ON THE SELECTIVE MECHANISM OF CHLORO IPC (ISOPROPYL N-3-CHLORO-PHENYLCARBAMATE)

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Abstract

The objective of this study was to determine what factor or factors were responsible for the tolerance of certain plant species to Chloro IPC.

A bio-assay for Chloro IPC, utilizing the elongation of the primary root of buckwheat, was developed. This assay was sensitive to concentrations of Chloro IPC as low as .01 ppm.

Eighteen different plant species were screened to determine the threshold concentrations of Chloro IPC necessary to cause significant inhibition to their primary roots. The species were divided into susceptible and resistant groups depending on their Chloro IPC thresholds. There was a greater difference between the means of the susceptible and resistant groups than between the means within each group. Above a threshold concentration, inhibition of the primary roots increased logarithmically with increases in concentration for both susceptible and resistant species.

Several experiments were conducted on the differential effect of Chloro IPC on buckwheat when exposed to resistant as compared to susceptible plant species. It was found that resistant species reduced the toxicity of Chloro IPC more than susceptible species under the following conditions: When plants were grown in the presence of Chloro IPC; when seeds were soaked in solutions of Chloro IPC; when seeds or seed parts were leached with water and the Chloro IPC added to the leachate; and when plants were grown prior to the addition of Chloro IPC.

Seed leachates of both resistant and susceptible species consistantly caused a depression of buckwheat root elongation. No physical treatment tried was successful in eliminating this inhibition. Leachates of the testa, whole seed, and cotyledon were compared to determine if any definite portion of the seed was responsible for this inhibition of buckwheat growth, or for the depression of Chloro IPC activity. The factor or factors responsible for Chloro IPC inhibition were apparently associated with both the squash testa and cotyledon.

Removing the testa from seeds increased the susceptibility of the seeds of both resistant and susceptible species to Chloro IPC.

Leaching whole squash seeds in running water caused them to grow better than unleached seeds. However, leaching cotyledons for progressively longer periods of time increased their susceptibility to Chloro IPC more than leaching the whole seed.

It is proposed that the selective mechanism of species resistant to Chloro IPC is due to a substance or substances produced by these species which in some way depresses the activity of the herbicide. It is suggested that the selective

mechanism would be much more efficient within the plant than outside of the plant.

SOME RESPONSES OF SEVERAL HORTICULTURAL PLANTS TO CMU, 3-CIPC AND DALAPON UNDER GREENHOUSE CONDITIONS

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Abstract

Three of the relatively new herbicides were tested under high temperatures (90 to 110° F.) on the following plants: common beet, cabbage, broccoli, turnip, muskmelon, cucumber, carrot, lettuce, tomato, parsnip, lima bean and sweet corn. These plants were started from seed in a loam soil in flats and treated either as pre-emergence or post-emergence applications. The herbicides were applied in 720 gallons of water per acre to allow for saturating the upper inch of soil next to, or in the vicinity of the seed. The chemicals were used at the following rates per acre: CMU (3-(p-chlorophenyl)-1, 1-dimethylurea) 1, 2 and 3 pounds; 3-CIPC (Isopropyl N-(3-chlorophenyl) carbamate) 2, 4 and 6 pounds; and Dalapon (a,a - dichloropropionic acid) 2, 4 and 6 pounds. Twenty-seven days following the CMU treatment, all the plants except carrot, corn and lima beans were dead and 53 days after the CMU application, these plants had also succumbed. The characteristic plant symptoms following treatment were yellow transparent leaf tissue followed by necrosis and shriveling of the entire plant. From cucumber, corn and asparagus seed planted in the CMU treated soil 105 days after original application, cucumber plants died, corn survived the 1- and 2-pound rates and was stunted at the 3-pound rate, and the asparagus grew normally at all rates. Twenty days following treatments with 3-CIPC at 2, 3 and 4 pounds per acre, the broccoli and the turnip plants were dead, and 30 days following treatment, the beet, cabbage, tomato and muskmelon plants were dead. Although the cucumber and lettuce plants showed some injury from the treatments, they survived the 53-day growing period. The carrot, parsnip, lima bean and corn plants apparently were not injured. The corn and lima beans showed an increase in fresh weight ranging from 5 to 35 percent over that of untreated plants. The tomato and beet plants produced a purpling of the underside of the foliage which was similar to that of phosphorus deficient plants. The other plants exhibited initial symptoms of light chlorosis at the base of the leaves which terminated in necrotic-appearing leaves. Except for the beet plants, all the other crops survived the Dalapon treatments for 53 days following treatment. Most of the plants had a stunted and retarded appearance together with chlorotic foliage. The corn developed into plants with the third leaf being tightly rolled at the middle and open at the tip, thus preventing complete unfolding of the succeeding leaves. The primary leaves of the lima beans were large, dark green and leathery in texture. The trifoliate leaves were completely inhibited. The carrot and parsnip plants were apparently not injured by Dalapon treatments.

THE CHEMICAL WEED CONTROL OF SOME ORNAMENTAL CROPS

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Abstract

There are many phases of chemical weed control on ornamentals. Our work is mainly on directive sprays on relatively dormant nursery stock, pre-emergence sprays on gladiolus, post transplanting sprays on growing plants, and non-selective sprays for the control of weeds between outdoor beds and under greenhouse benches.

For dormant nursery stock Dr. Pridham and I have found Dinitros and Chloro IPC sprays at 1/50 to be effective against chickweed, yarrow, annual blue grass and other weeds. The nursery stock is undamaged from the treatment. Pre-emergence sprays on gladiolus with Chloro IPC, 2,4-D plus NaTCA, and Dinitros followed by Crag herbicide #1 have given good early weed control. Other materials have given fairly good results also when the soil moisture was more favorable for weed seed germination.

Crag #1, Sesin, Natrin, and Alanap #2 were applied to carnations, weed control varied from poor to good depending upon location, while injury to the carnations varied from none to slight. With chrysanthemum, results also were variable but Crag #1 showed up well in most tests. Natrin proved to be rather harmful to roots in one field plot. Azaleas roots were severely injured by Crag #1 and Natrin, treated plants became chlorotic and eventually died. Sesin is the only one of the weed seed germination inhibitors showing promise with azaleas. Part of the sensitivity of azaleas may be due to their very fibrous root system. Chemicals for weed control under benches and between benches or beds of growing plants inside and outside the greenhouse are being tested. Steam, methyl bromide, chloropicrin, and other soil sterilization methods are occasionally most feasible as pre-planting treatments.

CHEMICAL WEEDING OF POTATOES

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Abstract

Weed control, with the potato crop, has generally been accomplished through the timely and frequent use of the weeder and the row-cultivator. In most years, and on many farms, these two tillage operations have provided good to excellent weed control through most of the growing season. However, late in the season, after it becomes impractical to continue use of the cultivator, weeds often come into a field and make harvesting very difficult. In recent years, with increased use of irrigation and larger increments of fertilizer, along with a consideration of tillage costs and possible damage due to tillage operations, many growers have become interested in the possible use of chemical methods of weed

control to reduce the costs and hazards of tillage, as well as to minimize the weed problems at harvest time.

During the summer of 1947, it was found that pre-emergence applications of one to two pounds of 2,4-D, per acre, provided effective weed control for at least five to six weeks with the potato crop, in studies at the Ohio Station. It was also noted that single post-emergence applications of 2,4-D could be used with a minimum effect on the potato, but that when multiple treatments (weekly intervals) were used, severe damage or death of potato plants resulted. Based on these studies, as well as results from other areas, a rather extensive study was initiated in Ohio in an attempt to evaluate the role of available herbicides in solving some of the problems of weed control in commercial potato production.

These studies were conducted during the past seven years and include: four years experiments on muck soils at The Muck Crop Farm Sub-Station, Willard; three years on Wooster silt loam at The Ohio Agricultural Experiment Station, Wooster; and seven years on Brookston and Miami silt loam at the Ohio State University Vegetable Farm, Columbus. In addition, certain cooperative studies with commercial potato growers in Ohio are included covering results of the past three years.

Chemicals included in these studies were: sodium and amine salts, esters, and low volatile esters, of 2,4-D; Crag Herbicide #1; MCP; CMU; dinitrophenols; pentachlorophenols; sodium pentachlorophenate; sodium trichloroacetate; Chloro IPC; ethyl xanthogen disulfide; and certain combinations of the above. Previous and concurrent studies revealed that delayed pre-emergence applications of herbicides (just prior to emergence of potato) were usually much more effective than treatments applied at or near time of planting, or at time of emergence. Therefore, most herbicide sprays were made as delayed pre-emergence treatments, although certain additional herbicide sprays were used including early pre-emergence, emergence, as well as over-all and directed post-emergence treatments. During the last two years, increased emphasis was placed on directed post-emergence sprays containing the amine salt of 2,4-D and sodium trichloroacetate.

Katahdin and Irish Cobbler varieties were included in most studies, while Russet Rural and Chippewa were included in only two studies. Potatoes were harvested from all treated and untreated plots and yields and grades were determined. In the last three years of the study, random lots of potatoes from treated and untreated plots were subjected to storage studies at two different temperatures and effect of treatment was determined as related to sprouting, weight loss, respiration rate, breakdown, as well as chipping quality.

Results. Delayed pre-emergence treatments practically always provided the best weed control for the longest period of time. With the esters and low volatile esters of 2,4-D and the dinitrophenol sprays, this effect was still present through the harvest period in many instances. With most of the other chemicals, the weed control value was usually limited to five to six weeks after application. Visible damage to potatoes, with most chemicals, was also closely associated with maximum delay in pre-emergence applications. Yield and grade response indicated that this initial damage due to delayed spraying was of minor consequence as compared with the more effective weed control. Chloro IPC and CMU were the only chemical treatments which resulted in excessive damage to potatoes when applied as delayed pre-emergence. Even with these chemicals, weed control was slightly more effective as compared with earlier or later spray applications.

Pre-emergence application of the various herbicides, at or soon after planting, provided variable weed control. In some seasons, weed control might be adequate for several weeks, and then again might be negligible. Visible damage to potatoes was usually associated with sprays of amine salts or sodium salts of 2,4-D or sodium pentachlorophenate applied at time of planting, and followed by heavy rains. Where pre-emergence sprays were delayed for two to six days after planting, visible damage to potatoes was minor, but weed control was often too variable.

Emergence sprays with dinitrophenols, ethyl xanthogen disulfide, pentachlorophenols, and often with one-pound rate amine salt of 2,4-D, resulted in rather severe burn or distortion of potato sprouts, but regrowth of potatoes was rapid and weed control was usually excellent. In general, however, there was usually not enough advantage in effective weed control to warrant using emergence sprays where delayed pre-emergence sprays of these chemicals could be made.

Directed post-emergence sprays with potatoes were found to be much more difficult to use effectively as compared with pre-emergence sprays. The best chemicals for this type of spraying were; sodium or amine salts of 2,4-D, for broadleaf weeds; sodium trichloracetate, for grassy weeds; and Crag Herb. 1, which often provided fair to excellent control of both grasses and broadleafs. Combination sprays of amine salt of 2,4-D at one-half pound and sodium TCA at five pounds have shown considerable promise in holding down weed growth late in the season, when applied as a directed post-emergence treatment.

Yields of potatoes from herbicide treated plots, have in general been rather disappointing. While there have been only one or two instances where treatments have brought about a statistically significant reduction in yield, there have only been a few instances where there have been significant increases in yield. Yields have in general followed a rather steady trend upward following use of herbicides. However, it is doubtful if the use of herbicides on most potato land would be warranted if one were to consider the possible increased yield as the major purpose for spraying. One of the important facts that has come out of these herbicide yield studies, is that the potato crop as grown today can tolerate rather serious weed competition before yields are affected. Therefore, on a yield basis only, the use of herbicides with potatoes would appear to be limited to particularly weedy fields, or fields of low fertility, or on non-irrigated fields where weeds would compete with potatoes for a minimum water supply.

If one ignores the goal of increased yields alone, and considers the ease and advantage of weed control that can be accomplished through the first six to seven weeks with herbicide sprays with no cultivation, or also considers the advantage of minimum weed problems at harvest time, then chemical weeding of potatoes holds promise. In some seasons, we have been able to reduce the number of cultivations to three, and their primary purpose was to keep soil up over the ridge to prevent greening of exposed tubers. At harvest time, these plots could be dug with a minimum

hazard from weeds. Adjacent non-chemically weeded plots, required the use of the weeder twice, were cultivated six times plus hoeing out of large weeds, and yet at harvest time it was necessary to mow the plots and remove weeds before digging was possible.

With most of the herbicides included in these studies, there was minimum evidence of varietal differences as related to specific treatment. The notable exception was however, the susceptibility of the Russet Rural variety to 2,4-D sprays. Emergence and post-emergence 2,4-D treatments with this variety often resulted in severe visual damage to plant as well as reduced yields. There was minimum evidence of differential varietal susceptibility with Kathdin, Irish Cobbler, or Chippewa.

Storage and quality studies of the potatoes harvested from the various herbicide treated and check plots did not reveal consistent significant differences which could be correlated with any specific treatment. While there were occasionally some differences in regard to number of potatoes per plot, U.S. Grade differences were usually less than five percent. Respiration rates of potatoes which had received post-emergence applications of 2,4-D were generally somewhat higher than the untreated potatoes, but these differences were usually not statistically significant. There were also some differences as related to delayed sprouting of potatoes in storage with 2,4-D and Chloro IPC post-emergence sprays, but these results again were not consistent. In general, it could be stated that none of the herbicides as used in these studies seemed to exert any serious effect on the potatoes held through the winter storage period. There are, of course, many other quality studies which should be made with herbicide treated potatoes before we can fully evaluate their effect.

CHEMICAL WEED CONTROL STUDIES WITH PEAS

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Abstract

In order that comparisons with other environments may be made to advantage it should be mentioned at the outset that soils at the University of Manitoba are a fairly heavy clay silt loam and that most soils where peas are grown for canning are relatively rich, heavy in clay and often rather poorly drained. Total precipitation is about 20 inches; just under half of which falls during May, June and July - the months when peas are being grown.

The major weed species causing difficulty is wild mustard, Brassica arvense. However, the wide use of 2,4-D in control of weeds in grain crops grown in rotation with canning peas has greatly reduced the stands of this weed and given rise to an apparent increase in wild oats, Avena fatua and green foxtail, Setaria viridis. The above 3 species have received the most attention in weed control studies with more emphasis on wild oats and green foxtail during 1952 and 1953.

Up until 1953, the di-nitros and particularly Sinox which had come into use some years previous were the general weedicides for peas in the canning area; giving good control of mustard and some other broadleaved weeds. In 1953 largely as a follow up of tests carried out over a 3 year period by the University of Manitoba (results of which have appeared in N.C.W.C.C. Research Reports) MCP, sodium salt was used at rates from 1 1/4 to 1½ ounces of active ingredient per acre. Regular 2,4-D low volume spray equipment was used to apply the chemical at approximately 5 to 6 gallons of solution per acre. Under the abnormally wet growing conditions which prevailed in 1953 (rainfall for May, June, and July was about twice the average) the advantages of the low volume applications compared to the di-nitro treatments were great. In general excellent control of mustard and false ragweed was obtained with no obvious harm to the pea crop. Canada thistle and stinkweed were noticeably stunted., Five varieties (Pacemaker, Early Perfection, Resistant Surprise, Thomas Laxton and Wisconsin Merit) were treated in stages from 4 to 8 inches in height and in no case was permanent damage noted.

Experiments were carried out at the University in 1953 to compare the effectiveness of MCP amine and MCP sodium salt. Unfortunately heavy rains in July which caused considerable flooding made yield data rather unreliable. Observations from plots treated pre-emergently with 3/4, 1½ and 2½ pounds per acre of the two formulations indicated very little difference in weed control and only a slight non-significant increase in yield reduction from the 2½ pound rate of the amine form when compared to the sodium salt form.

A comparison of MCP amine, MCP sodium salt and 2,4-D amine was made by applying the 3 chemicals post-emergently at the 3 rates 2½, 5, and 7½ oz. to Pacemaker and Early Perfection peas when the peas were 5 inches high. Excessive rains in July again made the gathering of accurate yield data impossible. Observations and such yield data as could be obtained indicated very little difference between either the weed control effects or the effects on pea plants which resulted from the two MCP formulations. The MCP amine at the highest rate gave some control of wild buckwheat Polygonum convolvulus whereas the sodium salt form was ineffective. At the 7½ ounce rate both MCP formulations caused definite but temporary twisting of leaf petioles and shoots and resulted in 3 to 5 days delayed maturity. Yields were only slightly reduced with both formulations of MCP; 2,4-D amine, however, caused striking significant reductions of 32 and 20% in yield of peas at the 7½ and 5 ounce rates respectively; and slight yield reductions at the 2½ ounce rate.

As indicated earlier wild oats and green foxtail are becoming increasingly serious in pea fields in Manitoba. Studies were begun in 1952 and continued in 1953 on methods of using IPC and TCA for control of these two weeds. IPC has been inconsistent in its effects on grass weeds at the University of Manitoba. In fact no successful weed control of any kind was obtained with this chemical in trials conducted over a period of several years previous to 1952. In 1952 IPC applied both pre- and post-emergently gave excellent control of wild oats but had little effect on green foxtail. Much rain occurred during the time of the post emergent applications and the soil was continuously wet to the surface for a period of several weeks following crop emergence. As this was the main difference between the 1952 season and previous seasons the excess moisture conditions were given credit for the effectiveness of the chemical. In 1953 a series of treatments were made with IPC at 2, 4,

and 6 pounds per acre worked into the soil to depths of 4 inches and 1½ inches just prior to seeding of crops to determine whether incorporating the chemical into moist soil would influence its effectiveness. These were compared with surface sprayed plots. Wild oats were effectively controlled with the 4 and 6 pound rates worked in to either 4 or 1½ inch depths. Surface spraying without working into the soil produced only slight stunting and reduced stands. Green foxtail was not controlled by any method of IPC application. In a similar series of tests with TCA at 4 and 6 pounds per acre, incorporating the chemical with the soil proved ineffective on either green foxtail or wild oats. Surface spraying either as a pre- or post-emergent treatment gave excellent control of green foxtail but had very little effect on wild oats.

None of the IPC treatments carried out in the field produced any measurable effects on the peas. Under greenhouse culture some rather striking effects have resulted. TCA slightly retarded the pea development and reduced the bloom on the foliage. It did not noticeably affect the pea yields at the rates used. More detailed studies are required to determine its safety with peas.

Endothal was included in the same study at rates of 6, 8, and 12 pounds per acre. It proved effective against both weed species regardless of the method of application but less so than the specific effect of IPC and TCA on wild oats and green foxtail respectively. Also it proved destructive to the peas at all rates and with each method of application used.

SOME FACTORS AFFECTING THE TOLERANCE OF PEAS TO MCP

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Abstract

Weed infestations in canning peas frequently reduce yields of shelled peas and fragments of weeds are difficult to remove from the pack. No herbicide has as yet come into widespread use in this crop. Herbicides of the growth regulating type are known to control broad-leaved weeds but these herbicides have usually injured leguminous plants too severely to allow their recommendation for use on the pea crop. Occasionally satisfactory weed control has been obtained in peas with some of these herbicides without appreciable injury. Since results have been erratic it was desirable to initiate a study of the factors affecting the response of peas to herbicides of this type.

Results during the years 1949 to 1953 have shown that MCP is less toxic to peas than 2,4-D. 2,4,5-T, 3,4-dichlorophenoxyacetic acid and 4-chlorophenoxyacetic acid have also been found to be relatively non-toxic to peas. They may be of value for use in this crop if further trials indicate that they give satisfactory control of weeds. The use of amine or sodium salt preparations of MCP was considerable less hazardous than the use of ester preparations. Amine preparations gave no yield reductions in any of the trials when applied to peas about 6 inches tall at rates of 0.5 pounds per acre using water equal to 40 gallons per acre. Reductions in yield occurred frequently when the peas were treated with 0.5 pounds ester per acre. Treatment at the degree of safety in these trials. In some instances no yield reductions occurred from treatments made up to the bud stage. Occasionally injury occurred to peas only 10 inches tall when treated.

The volume of spray used to apply the MCP was of considerable importance. The less concentrated sprays caused less injury to the peas than the low gallonage, concentrated applications. This factor was nearly as important as application rate on peas. The use of low gallonage sprays may be responsible for some of the reductions in yields of peas that have been noted following use of this herbicide.

All but the lowest applications of MCP tended to delay the maturity of the peas. Since yield of shelled peas is closely correlated with maturity it is likely that many of the differences in yield are more apparent than real. Allowing peas that have been treated to develop to the normal canning stage reduces or may eliminate the reductions in yield that are often present when treated and untreated peas are harvested simultaneously.

On the basis of the data available it appears that MCP is a promising herbicide for the control of annual broad-leaved weeds in peas provided that the amine or sodium salt preparations are applied to peas about 6 inches in height at rates of no more than 0.25 pounds per acre in spray volumes of not less than 20 gallons per acre. If weeds are prevalent increases in yields of shelled peas can be expected when these restrictions are followed. The more tolerant weeds might be treated under similar conditions with up to 0.5 pounds of MCP per acre but considerable delay in maturity and some reduction in yield is probable.

PEA WEED CONTROL

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Abstract

Pea weed control studies have been conducted in the Northeast by Birds Eye Horticultural Research since 1948. The primary object of these trials was to control broadleaf weeds, mainly mustard. Although several weed control chemicals have been investigated, the Dinitro sprays have been the most practical to use and have been the most consistent in giving good weed control without crop injury. Substantial pea acreage has been sprayed annually with the ammonium salt of DNOSBP, and commercially acceptable broadleaf weed control has been obtained.

In 1952 investigations comparing various spray volumes of the ammonium and amine salts of DNOSBP indicated that the amine form was equally effective or better than the ammonium salt for weed control in legume seeded peas. Acceptable weed control was provided at 3/4 pound active Dinitro in volumes as low as 12 gallons per acre when spray application was made at average midday temperatures of 75 degrees F. Pea and legume under-seedings were not injured. Reduced volumes of the ammonium form of DNOSBP, however, caused varying amounts of pea and legume

injury and tended to reduce yields. The 1952 studies also indicated that MCP was a very effective weed killer but caused serious injury to peas and alfalfa seedings when used at 1/2 and 1/4 pounds per acre in 50 or 12 gallon spray volumes.

In 1953 experiments were conducted to further investigate the effect of various volumes of amine and ammonium DNOSBP sprays on pea yield, weed control, and pea and legume injury, especially when applied at temperatures lower than 70 degrees F. As a part of this study MCP sprays at 1/8 pounds per acre were also investigated.

Dinitro sprays, regardless of the form used, were found less effective when applied at 57 degrees F. than at 75 degrees F. All sprays, however, significantly reduced weed populations which resulted in increased yield when compared to that of the check. There was no apparent pea or legume injury nor were clover or alfalfa stands significantly affected by any of the spray applications. There was no significant difference between Dow Selective (ammonium form) and Premerge (amine form) as far as weed counts were concerned. There was, however, a tendency for weed populations to be reduced at the 12 gallon volume, although this was statistically significant only for the Premerge sprays. Weeds not completely killed were more stunted or injured by the Dow Selective sprays than by Premerge. This was strikingly borne out by the heavier weed weights obtained from the Premerge plots. Pea maturity, as indicated by tenderometer value, was not affected by spray volume or chemical. Reduced volume of Dow Selective sprays had no significant effect on pea yield or weight of pea vines. As volume of Premerge sprays were reduced, however, there was a significant increase in pea yield, vine weight, and total peas per plant. Pea vine weight and total peas per pod were greater from the plots sprayed with Dow Selective at 25 and 50 gallons per acre than from the corresponding Premerge plots. These data together with the trend toward better weed control from lower volume sprays strongly indicate that Premerge is safer to use from the standpoint of crop injury and can be used more effectively at lower volume. Previous investigations have revealed that Dow Selective sprays cause pea and legume injury when volumes less than 50 gallons per acre are used at temperatures about 75 degrees F. Under comparable conditions Premerge sprays caused no injury.

MCP sprays at 1/8 pound (acid equivalent) in 25 and 12 gallons of water per acre caused no apparent injury to peas and legume seedings. Weed control was equally as good as that obtained by the Dinitro sprays. MCP, however, was much slower in its action and those weeds not killed were severely stunted. Average weed weight in the MCP sprayed plots varied from 1.2 to 1.5 grams as compared to 3.3 to 7.9 grams in the Dinitro sprayed plots. MCP sprays had no significant effect on pea maturity, clover and alfalfa stands, or pea yields, which were equally as high as those sprayed with Dinitros. Previous data have indicated that MCP at 1/2 and 1/4 pounds per acre caused severe pea and legume injury and reduced pea yield. This would indicate that MCP at 1/8 pound per acre may be suitable for pea weed control.

WILD OAT CONTROL IN DRY PEAS

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Abstract

Dry peas are an important field crop in the Pacific Northwest. During the 12-year period from 1940 to 1951 there was an average of 364,000 acres producing a crop worth $20,000,000 annually. This was 83 percent of the U. S. acreage and 86 percent of the U. S. production of this crop. The average yield during the 12-year period was 1260 pounds per acre which is somewhat above the national average. This important crop is subject to many weed problems since peas are poor plant competitors. The major grass-type weed causing trouble is the wild oat and many broadleaved species also cause considerable trouble. As a consequence, the Idaho Agricultural Experiment Station in cooperation with the U. S. Department of Agriculture started an intensive study of weed control in this crop in 1947 and this program is still in progress. Early tests showed that as long as wild oats were present in large numbers the elimination of the broadleaved species was of little benefit to the pea crop and hence wild oat control must take precedence in an overall weed control program in dry peas.

Preliminary tests made in 1947 and 1948 indicated that IPC (isopropyl-N-phenylcarbamate) held possibilities of a method of wild oat control in a wheat-pea rotation and as a consequence detailed tests of this material were started in 1949. During the past five seasons various phases of the problem have been studied. These include: first, rates of application; second, dates of application; third, methods of application; fourth, types of material; fifth, carriers and carrier volumes; sixth, depth of working; and seventh, other chemicals that might be better. Generally the results obtained from treatments with IPC have been steadily improved over the years and the cost of the treatment reduced. At the present time control of 95 to 100 percent is common at a cost of about $8 per acre.

Two things have been shown to be of particular importance in treating peas with IPC for wild oat control. These are: first, uniformity of application of the right amount of material; and second getting the material in contact with the germinating wild oat seed. Tests have shown that on the average this can best be done by spraying four pounds per acre of regular IPC just prior to seeding in the spring and thoroughly working the material into the soil to a depth of at least three inches and preferably six inches. The non-emulsifiable form may be applied in diesel oil using 5 to 10 gallons of total solution per acre, the emulsifiable form in 10 to 20 gallons of water per acre or the wettable form in 20 to 40 gallons of water per acre. Other things being equal the application of the non-emulsifiable form in diesel oil has generally given better results at a lower cost than the other forms. Dry applications have not been as satisfactory as spray applications. For the dry pea area the carbamates have been superior to any other material tested for wild oat control and IPC has been equal to or superior to any of the other carbamates tested. Rates in excess of four pounds per acre have caused injury to the pea crop on heavy soils low in organic matter when the planting season was cold and wet. When applications of IPC were properly made under conditions of heavy wild oat

stands, yield increases from 200 to 1,200 pounds per acre have been obtained on peas and from 10 to 20 percent increases in the yield of the following wheat crop. This has meant an average return of about $3 in peas for each $1 expended on IPC.

The first commercial applications of IPC for wild oat control in peas were made in 1951 with about 200 acres being treated. This increased to about 7,000 acres in 1952 and to between 12,000 and 15,000 acres in 1953. Further increases in use may be anticipated in the future since it would appear that at present prices around 20 percent of the dry pea acreage could be economically treated each year.

The use of IPC is not the final answer to the problem of wild oat control in the dry pea districts but when properly used in combination with good crop rotations and cultural practices, it should be of considerable benefit in crop production and weed control until a better method is developed.

ABSORPTION AND TRANSLOCATION OF HERBICIDES

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Abstract

In order to kill roots of plants following spray application to the foliage a herbicide must penetrate the cuticle, move into the mesophyll cells of the leaf or stem, migrate to the phloem and there translocate to the parts below ground. The cuticle is a fatty or waxy layer, impervious to water and other polar compounds. Dinitro compounds and 2,4-D penetrate the cuticle most readily in the form of the undissociated parent molecules.

To part from the cuticle and migrate across the mesophyll, 2,4-D compounds should be somewhat soluble in water. Salts of the parent acid most nearly meet this requirement. To meet the combined requirements of cuticle penetration, partition to the mesophyll and migration to and within the phloem the emulsifyable acid and glycol ester formulations seem best.

Studies with radioactive 2,4-D show that this compound in the acid form penetrates the cuticle, moves to the phloem, and there translocates with food material in the plant. Tests on beans, cotton, cucumber, and barley all show comparable results.

Tests on wild morning glory plants in the greenhouse and in the field prove that radioactive 2,4-D is readily absorbed by cotyledons and young leaves and transported to roots of small seedlings. In larger plants treatment of a lower leaf resulted in movement into the roots; treatment of a young tip leaf resulted in no translocation, or translocation to the tip. In old plants in the field translocation in active growing plants was downward from basal leaves, upward from tip leaves, and both directions from leaves in the middle of the stem. Movement into horizontal roots occurred as readily as into vertical ones. In order to kill roots of perennial weeds with 2,4-D it is as important that growth be taking place as it is that translocation occurs. Translocation takes place into storage roots but apparently the tissues are not killed.

TRANSLOCATION OF 3-(p-CHLOROPHENYL)-1, 1-DIMETHYLUREA IN PLANTS

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Abstract

In order to determine whether CMU moved in the plant, C^{14} ring-labeled CMU was synthesized and used in solution culture studies. Because of the ease of culturing and the adaptability to the tracer techniques, tomatoes were used for these experiments. The concentrations of CMU in the nutrient solution were such that kill of the plants would normally be obtained in about ten days. Tomato plants thirty-five days old growing in a nutrient solution containing 0.25 parts per million of C^{14} ring-labeled CMU were used. At two-hour intervals for the first 12 hours and at 24-hour intervals thereafter up to six days, single plants were removed, the roots washed in three rinses of water, and each entire plant pressed between blotting paper. All plants were pressed with the foliage on one side of the main axis placed with the adaxial surface upward and foliage on the opposite side with abaxial surface upward. Pressed plants were kept in a warm room and the blotting paper changed frequently to insure rapid drying. After air-drying, specimens were placed in contact with X-ray film for a period of 22 days.

It is of interest to note that an appreciable amount of C^{14} was present throughout the aerial portions after an exposure for two hours to the CMU treatment. The concentration of C^{14} in the roots of the tomato increased very gradually throughout the period of treatment whereas the concentration in the aerial parts of the tomato increased quite rapidly during the experiment. This distribution effect was further defined by more precise quantitative measurements of C^{14}.

Tomato plants growing in nutrient solutions containing ring-labeled CMU were sampled at the same 12 intervals of time after treatment and radioassayed for C^{14} by the windowless counter method. Older plants were used in this experiment to provide sufficient bulk for the analysis of various plant parts. The use of older plants also necessitated the use of higher treatment concentrations of CMU for similar effects.

Again, rapid upward translocation was noted. Seven parts per million of CMU as calculated by radioassay of C^{14} were accounted for in the upper portion of a tomato plant with roots exposed for two hours in a nutrient solution containing 2 parts per million of CMU.

To determine the extent of downward translocation resulting from foliage treatments, leaf tips of tomatoes were submerged in ring-labeled CMU solutions (10 ppm) for a period of 24 hours. Radioautograms of these plants showed little C^{14} below the area of application. In a second experiment, small quantities of CMU solutions were applied in lanolin rings over the midrib of tomato leaflets. The portion of the tomato leaflet distal to the treated circle showed typical visible CMU toxicity symptoms whereas no visible symptoms were apparent below the treated area. Radioautograms confirm that there was very little movement of C^{14} downward in the treated leaves. This suggests that translocation of CMU in plants is mainly in the xylem.

These same experiments were also conducted using monocotyledonous plants such as corn and Johnson grass seedlings. The data obtained indicate the same general trends as with the work on tomatoes, namely that translocation upward was very rapid but that downward translocation was nil.

It will be noted from these data that the amounts of CMU in plants can be high when these are grown in solution culture in the presence of relatively high concentration of CMU and when the samples are taken immediately after treatment. It is apparent, however, from our work that such amounts of CMU are not found in crops which have been treated with pre-emergence applications of CMU. A large number of analyses have been conducted on crops and in all of those studied, which includes such crops as corn, onions, asparagus, pineapple, sugar cane, and cotton, the average amount of CMU in the plant has been 0.1 ppm or less. Data on crop analyses will be published in due course.

While these investigations demonstrate the pattern of movement of C^{14} in plants treated with radioactive CMU, it is recognized that they do not establish beyond doubt the translocation of the intact CMU molecule. Experiments to clarify this point are being conducted.

TRENDS IN TEACHING WEED CONTROL

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Abstract

We, who are interested in planning and carrying out educational programs in agricultural work must keep in mind that farm operators and farm managers are busy individuals and becoming more so as new scientific methods are being introduced and demands for increased production become apparent. Since he is a busy individual he will seek information through channels that take the least amount of his time. He may not find time to attend many meetings or may not be inclined to do so if he can obtain the information desired by reading publications, listening to the radio or watching television. Incidentally a recent survey made found that more than 30 percent of Indiana farmers have television sets. Here alone is a challenge to those who are interested in reaching the farmer.

An abundance of weed control information is now available. This is the result of recent research. Much of the newest information is of a technical nature and requires considerable study in order that it may be properly applied. Fortunately, farmers have learned how to use sprayers, and are somewhat familiar with many herbicidal terms. The educational program is "over the hump" so to speak as far as teaching techniques in chemical weed control is concerned. More educational work along this line is needed however.

Farmers are not the only ones interested in weed control. The field is much broader than that. Industrial firms, especially those in charge of utility lines, railroads, highways and many others have weed control problems and rely upon research and educational agencies for their information. Many weed control problems are of public interest making it necessary to coordinate the program so as to satisfy all concerned. The general public is concerned about the destruction of certain types of vegetation.

Since we are principally concerned with the teaching of adults, methods of teaching must stress the how rather than the why of what is being taught. Adults are living now. They have to solve a problem now. Therefore what is taught must be of immediate aid. This does not mean that reasons for so doing should not be taught. On the contrary often the most simple procedure of explanation is to tell why things happen as they do. Many of you will remember the curiosity regarding how 2,4-D kills plants. Merely stating that it killed weeds and how the material should be used was not enough. A discussion of this phase of weed control should include statements regarding the nature of 2,4-D, how plants absorb the material and if possible what physiological action takes place in the plant.

To be most effective an educational weed control program must reach all the people interested in the subject. In a long time program of teaching weed control the younger generation should not be forgotten. 4-H members, high school and college students should have an opportunity to learn the fundamentals of plant identification and control. To this group fundamentals and principles should be taught as they are and should be primarily interested in learning for the purpose of understanding. With the inevitable changing conditions, techniques which apply today are not as important to them as principles which they may apply in the future.

When teaching adults the teacher should recognize that there are two types of purposes dominating this group. One may be classified as the "action purpose", the other the "knowledge". The action group is interested in knowing how to get the job at hand done, the knowledge group is interested chiefly in knowing for the purpose of understanding. In the action group are leaders, farmers, dealers in materials and equipment used, and others actively engaged in weed control. It appears logical to believe that it is in this group that greatest returns or adoptions of practices taught will be made because of their present interest. They either have a weed problem to solve or are engaged in making a living which depends on the extent of activity in this field. Others are those whose interest is mainly that of a desire to learn and understand and should not be neglected entirely. This group usually is interested in the why rather than the how of happenings.

We must use all means and teaching methods available to convey the message to those concerned with the problems of weed control. When teaching adults, changes in behavior and practices are affected by the number of contacts made. The degree that rural people are exposed to information through meetings, demonstrations, bulletins distributed, news stories, radio talks, personal contacts and other teaching aids and devices will directly influence their acceptance of recommended practices. Some studies have shown that as a number of different types of contact to the same information increases from one to nine different kinds, the number of acceptances of the practice taught increases from 35 to 98 percent. This increase is very rapid as the contacts increase through the use of five to six different teaching aids. Repetition in a variety of ways and means is exceedingly important to learning.

TEACHING AIDS IN WEED PLANT AND SEED IDENTIFICATION

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Abstract

The basis for a sound weed control program is the ability of the majority of the people to identify weed plants and seeds. Too often a patch of weeds becomes a menace to the community before it is realized the seriousness of it. Lack of interest in identification caused us to investigate methods, aids and techniques as to how we could best reach and teach people, both adults and youth, to identify weed plants and seeds. Our approach was through weed plant identification mounts, weed seed identification boards and through the use of slides. We also utilize tours, field trips, Botany Schools, etc. I will emphasize aids that have been constructed for general use for indoor meetings. May I say at the outset that there is no best way. We need to utilize every way at our command.

Weed plant identification mounts. To meet the need of weed plant identification, sets of twenty weed plant mounts were developed. These included the 8 primary noxious, 8 secondary noxious and 4 common weeds that cause farmers losses. Each mount is numbered from 1 to 20. These are laid out on tables with spacing between mounts depending on the number of people participating. This is nothing new. It is our approach that was different to obtain participation. Multiple choice forms were developed. These are numbered the same as the mounts. After each number are 3 to 5 names of weeds one of which is the same as the mount. The one which is felt correct is underlined.

Why do we use multiple choice answers? Using multiple choice we found that participation was nearly 100% where as when participants were required to identify and write the name of the weed very few would take part.

Weed seed identification boards. As in the case of the weed plants an effort was made to make the seed identification project self teaching. The boards are constructed of 3/8 inch tempered masonite 16 x 21 inches. The seed wells are 3/4 inch in diameter arranged in a diamond shape with our 8 primary noxious weeds at upper and 8 secondary noxious weeds at the lower portion of the board. The backs of the seed well are covered with white tagboard and caps are of .001 plastic cut by a die. M31 plastic cement available from Minnesota Mining and Mfg. Company was the only material that would hold the plastic caps. White or clear cement was desired but not available. The printing was done by silk screening. Milo Potas, Extension Visual Aids Specialist prepared the boards. A jar (2 x 3 1/4 inches) half filled with grain plus a supply of the 16 weed seeds is emptied onto the board and through a process of matching the seeds they learn to identify them. The characteristics of perennial sow thistle and canada thistle, perennial peppergrass and pennycress are difficult to see; therefore, a magnifying lens should be available. It will be necessary to give some help with the seeds mentioned above.

Slides of plants and seeds for identification. The Extension Visual Aids Department assisted with the photographing of plants and seeds that were developed into colored slides for identification. A few slides will be shown to illustrate the type of material. Slides are useful to teach identification to larger groups. However, the retention of information is not as great because generally too much material is presented and insufficient time is permitted for the individual to give any one slide proper study. If the slide is left on the screen any length of time people become restless.

To be effective weed plant slides should be taken at many stages of growth during the year. This is difficult for us. We should like to develop our set to show stages of growth of the seedling, root system, mature plant, blossom, identifying characteristics of the plant and seed.

The weed seed identification slides were taken using portra lens on a 35 m.m. camera with kodachrome film. Two photo flood lights were used to give sufficient light. The slides were taken at a distance to provide the natural size of the seed (note the common pin).

A STATEWIDE EXTENSION PROGRAM IN WEED CONTROL

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Abstract

In the short time available on this program, I will attempt to report on the organization, methods used and results obtained in the Extension weed control program in North Dakota in 1953. I am not holding up our weed program as a model or ideal but rather as a report on how it is being done in one state with the hope that a few of the ideas may be helpful to others.

In organizing a 1953 weed control program, the ideas of many farmers, County Agents and other Agricultural agency personnel were coordinated by the Extension Agronomist into a tentative weed program. This program was then presented to the county agents of the state at a series of district conferences held in November of 1952. After some adjustments and amendments, a state weed program was agreed upon.

The main phases of our program included getting out information to farmers of the state, providing information and training to the county agents, conducting sprayer calibrations and information meetings by county agents for farmers in each county, organizing a leafy spurge demonstration program, a roadside spraying program, cultural control information and recommendations and a statewide survey to determine results obtained.

In providing information to farmers, six bulletins and circulars containing chemical and cultural weed control recommendations were prepared with the cooperation of the Experiment Station personnel. 37,251 publications were distributed to farmers throughout the state in 1953 and 16 county agents sent out circular letters to all of their farmers in regard to the weed program. 282 meetings were held throughout the state on weed control with a total attendance of

16,998 farmers. In the way of publicity, the Extension Agronomist prepared seven weekly suggested news stories which were sent out to county agents to be adapted and used locally. As a result, 438 news stories were published in the state and 150 radio programs were devoted to weed control.

Farm sprayer demonstrations were used as a medium of not only suggesting maintenance adjustment and calibration of farm sprayer but also as a means of attracting crowds at which general information could be presented by county agents on weed control. A series of training meetings were conducted with the cooperation of the agricultural engineer for county agents at a series of district conferences in May. County agents then conducted 66 county sprayer calibration demonstrations and meetings with a total attendance of 2,535.

As leafy spurge is one of the most widespread noxious weeds in North Dakota, special emphasis was given to chemical control demonstrations on leafy spurge. With the cooperation of commercial companies and the Experiment Station, plans were organized, chemical provided free of charge and directions furnished for applying seven square rod treatments of 2,4-D and soil sterilants on leafy spurge infestations. County agents applied the chemicals and will follow up the demonstration with the necessary retreatments for a period of five years. As a result, 54 leafy spurge demonstrations were conducted in 40 counties in North Dakota in 1953.

As the demonstration is still the most effective teaching aid in any educational program, demonstrations were stressed in the 1953 weed program. County agents organized and carried out selective weed control demonstrations with a check strip being left for comparison on local farms. Such demonstrations conducted in North Dakota in 1953 included 156 with 2,4-D, 12 with MCP, 42 with TCA, and 21 with both TCA and either 2,4-D or MCP. Yield results were obtained from ten of these farm demonstrations part of which were harvested by farmer combine method and others by samples sent in to the Extension Agronomist for threshing and yield calculations. Two of the demonstrations on wheat and oats showed slight decreases as a result of 2,4-D treatment. The other eight demonstrations on both small grains and flax showed substantial yield increases for the chemical weed treatment varying from $2\frac{1}{2}$ to 7 bushels increased yield.

A county roadside spraying program was one of the phases of our weed control program. There is still a lot of room for improvement in this phase, although, counties are showing a lot more interest each year. Assistance was given to the county agent and county commissioners in 13 counties in 1953 in organizing and planning their roadside spray program. 129 townships cooperated, 3,675 roadside miles were treated with patch treatment being applied on noxious weeds for 6,495 roadside patches and 938 patches in ajoining crop land.

To determine results obtained in the 1953 North Dakota program, a questionnaire was prepared by the Extension Agronomist and sent out to the county agents. Using the data available together with their own observations and estimates, county agents reported county weed control which was summarized for the state. In addition to other data reported earlier, this survey shows that chemical weed control was applied in 1953 on 2,125,830 acres of small grains, 479,595 acres of flax, 8,655 of corn, 65,805 acres summer fallow, 27,840 pasture, and 3,831 acres of other crops and uses totaling 2,711,556 acres treated in 1953.

In equipment used and methods of application, the survey indicates that there are 12,657 farm sprayers in use in North Dakota, 429 ground dusters and 129 airplanes that applied chemical weed control in 1953. 88% of the application was made by ground sprayer, 2% by ground duster, and 10% by airplanes. In soil sterilants applied in North Dakota in 1953, the survey indicates totals of 151,926 pounds of sodium chlorate, 9,600 pounds of borate, 41,886 pounds of borate-chlorate material 25,800 pounds of atlacide, 345 pounds of CMU, and 7,400 of other chemicals. 18 counties handled these soil sterilants and in other counties they are handled by commercial dealers.

THE ROLE OF EXTENSION AGENCIES AND ACTION AGENCIES IN A WEED CONTROL PROGRAM

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Abstract

Definition of agencies. The extension agencies may include County Extension and State Extension Agronomists, and Crop or Weed Specialists.

In Wisconsin the action agencies that work on the state level carry out the provisions of the law as it relates to weed seeds in seed grains, grasses and legumes in small or large amounts. But as to any legal responsibilities throughout the state, beyond arranging meetings for weed commissioners and town chairmen and interpreting the laws, it has no power to initiate or carry through legal procedures. This power is given to local town boards - and in but 2 counties - to the county set-up of weed commissioners and its deputies.

1. Agencies must understand one another.
A. While the extension agencies have to do with the informational angle of a weed program, the legal phase of weed control need be known, and extension agencies talk and live weeds because of their economic importance, and weeds need not be eradicated because the law says so, but because of their effect in efficient farming programs. The extension agencies in keeping with their appointments may help interpret regulations, but further than that have limitations. Extension agencies need have a very close tie-up with action agencies so as to prevent duplication of efforts, and to better know where and what needs emphasis, but I feel where they have made definite plans and carried them out to fullest extent and has been giving full cooperation with action agencies, that the purpose of the program, which is weed control, will be realized and each agency will receive credit in response to their efforts.

Action agencies, who have the responsibility of enforcing the regulations, surely need to have quite a definite knowledge of weed eradication procedures to do the best in their own field. There should be a definite and common knowledge of both agencies on the types of weeds, the efforts local people have exercised in informing the farmers of existing situ-

ations and various methods for bettering the situations that are being carried on.

(B) Another role that perhaps extension agencies and action agencies need get together on is on weed seed prevention measures. Often I lament the fact that government, state and counties have used so much money building up strong weed control agencies, and on the other hand this has been partly counteracted, nearly all the efforts knocked into a cocked hat, by weed seeds of very noxious character permitted to be brought in through farm grains and legume and grass seed sales.

I don't believe local agencies, or extension agencies, have been consulted often enough as to weeds that should be considered in our seed laws. Often times weed seeds from very noxious, and what developed as very troublesome weeds have been tollerated until so bad that control procedure was nearly impossible - and now at this stage thrown into the laps of extension people and farmers. While had it been given early consideration with the good cleaning equipment that is now available, its spread could have been very definitely prevented. Two weeds that come in this category in Wisconsin are the White Cockle (Lychnus alba) and Hoary Alyssum (Bertoroa incana.)

(C) When tests have been made showing definitely that many weed seeds need be ground fine as 3/64 size in order to destroy them, and yet carloads of weed seeds are brought into our state where, to be used as dairy and beef feed, have to be ground quite coarse, then distributed through our territory unchallenged as to freedom of viable weed seeds - it would appear that both extension and state action agencies could to advantage work together on preventative measures.

2. Need for more education. There must be the need for more education because so many people think the same way. Yet we know that in the seed adulteration program the sellers' education comes from the printed word. The violaters may or may not attend meetings, but it's there in the regulations. How many millions of words have been spoken to farmers, published in books, papers and bulletins and over the air, and yet when the question of violations arises we are likely to hear "Well, farmers need more education."

3. Has extension slipped a cog or stripped a gear? Being in extension work for many years - both from a county and state level - I do appreciate the part that education takes and have always maintained when lack of a good weed control program is evident, it must be that we as extension agents have slipped a cog someplace along the line. Personally I don't know how long or how many years duration we should shoulder the blame for shiftless, just plain negligence in a weed control program. It is true that more efficient methods of weed control are being formulated and advanced yearly, and that new faces appear annually among the farm groups, but if the most improved methods of contacting people have been practiced by extension men at meetings, demonstrations on community levels, use of the printed word through circulars, newspapers and over the air contact and there still are those that don't care - just where is the logical follow-up to correct this, if it isn't the action agencies function?

4. Should weed control be considered more serious? Weed control, as I view it, comes under the same category as contagious diseases. In Wisconsin at least, long ago the legislature and various departments decided that education on disease losses, education on methods of spreading diseases, education on enormous profits from producing and marketing disease-free livestock and livestock products - all this was not enough. It left the "Farmers who cared" helpless if along side him existed one of these shiftless producers who had a million excuses why he should not conform to society's demands, or to regulations that he did not help formulate. So enforcement became a necessity wherever the "man who cared" was given an even break. At least this has been true from the state level but in weed control no powers have been vested in the state level, but shifted to local levels where troubles a plenty interfere with enforcement of non-compliance.

5. Don't necessarily need to antagonize our farmers. Those of us working for more efficient farm production, more appreciation for farm life, can't afford to antagonize our clientele. But, if we hold the hand of righteousness high, we can't overlook the complacent, the non-cooperative farmer who prevents area-wide adoption of up-to-date practices on weed control, causing undue hardships to those who care.

There is plenty evidence that where continued negligence exists, complacent members of society should be reprimanded, and if necessary to hold them responsible for their misdoings. Such action will receive far more compliments and do far more good than continued efforts attempting to compromise - to soft pedal and evade the situation.

Extension agencies have a real job analyzing the problems and solutions of same with local people. It is very essential however that local favor be won, even if action agencies take over and our people are to be left sweet - and continued harmony is to be found in carrying out any efficient farm weed program.

It would appear to me that we have sufficient evidence and examples in many lines of efforts to warrant more action in bringing about order in the house of weed control.

6. Perhaps extension needs enforcement to make programs effective. I often wonder what the "Stand by farmer" thinks of the line of thought and argument that extension forces put forth in attempting to get farmers excited to action over weed control. Are the arguments about weeds that refer to total losses, extra cost of production, influence in quality of products, health of livestock and the human family earmarks of a good farmer who cares for his neighbors. It must be where anyone can evade laws entirely to extent of ignoring his community responsibility, irregardless of his personal losses, that surely it goes out of the scope of the extension agencies, but for society's good should be handled without any question by action agencies. Surely if local people need reinforcement from state levels to improve the morale of those trying to keep peace in the family, also to protect the innocent - such assistance should be forthcoming.

RESPONSIBILITIES OF AN EXTENSION WEED SPECIALIST

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Abstract

The job of extension weed specialist has many responsibilities in common with all extension specialists but it also has certain responsibilities that are peculiar to weed control. Weed control is a new and developing field. The background of knowledge is not great and developments are rapid and far reaching. Emphasis on weed control in the last ten years has been on research. It would seem that it is now time to develop parallel emphasis on extension.

There are six areas of responsibility or six jobs that the extension weed specialist must do. The first of these is subject-matter leadership. This is, in part, the exercise of judgment in the selection and application of information. It is more than this, however; it is also the responsibility of keeping ahead of the field. It requires a continous study of field needs, a close relationship with subject-matter divisions and access to information and experiences of other colleges and organizations.

The second responsibility of the extension weed specialist is county staff training. With the county staff the keystone of our knowledge and guidance to the county staff. It is the job of the specialist to see that the county staff is supplied with the best in subject-matter and with the techniques for using it.

This responsibility presents certain problems peculiar to weed control. Most of the county staff have been trained in other fields. Weed control is a relatively small segment of their county responsibility and must be fitted into an already full load of other information that they carry.

County staff training leads naturally into the third field of responsibility - assistance in county program planning. I would emphasize that the role of the specialist is in assistance to the county in planning their own program. The responsibility for the county program belongs to the county staff. How well they carry this out may depend on the job the specialist has done in county staff training.

The fourth area of responsibility of the specialist is in liaison with the experiment station. This is a major responsibility. There are many divisions or departments contributing information to the field of weed control, and the specialist must be familiar with the work of all of them. It is the responsibility of the specialist to carry information out toward its application to the problems in the state and to bring in information to stimulate and guide research. He must interpret the work of the experiment station for the county staff and for the farmers. Although the specialist participates to only a limited extent in research, he must be qualified to meet the research worker on equal terms. In this area, again, subject matter leadership is of paramount importance.

A somewhat similar but broader area of responsibility is the fifth one - relationships with related agencies. There are many groups in the field of weed control and we need to be in close touch and on working relations with all of them. These groups have much to contribute to our program just as we may hope to contribute to theirs. In this group I would include the commercial organizations who can do much to help us with our programs in weed control.

The sixth field of responsibility is held in common with all extension workers. That of selling extension. As representatives of the extension service we bear the responsibility of representing extension and of generating an appreciation of the role of extension in the development of agricultural production and in rural living.

No two specialists will do the same job in the same way or will emphasize quite the same things. Programs in the various states must differ because of different needs. We have a common interest, however, in the future of weed control. We must develop enthusiasm and support for extension work in weed control to parallel that now given to research.

SCREENING BREEDING STOCKS FOR HERBICIDAL TOLERANCE

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Abstract

The development of new varieties is an important part of any crop improvement program. Testing these varieties is an important step in their development. Not only do the testing trials materially aid the plant breeder in his selection of material but they also provide the information for a description of a variety after it has been released to farmers.

Pick up any folder on new varieties and you will find a detailed account of the yield, strength of straw, maturity, disease reaction, and commercial quality of each. These data are the result of carefully conducted tests. Grown in rod rows and drill plots, these varieties are observed for their yield and agronomic characters. Grown in disease nurseries and under disease epidemics in the greenhouse, they are classified for susceptibility or resistance to the attacks of various pathogens. Subjected to milling, malting, and oil tests, they are rated for commercial value. These facts make up the descriptive history that accompanies the release of each new variety to help the farmer make an intelligent choice for his situation.

It is our opinion that the response of varieties to herbicides also should be included in these descriptions as rapidly as reliable information can be obtained. That there are varietal differences in response to 2,4-D has been demonstrated in flax, corn, oats, barley, and sorghum. In some crops, these differences have been considerable. For instance in flax, Redwing has shown no injury from four times the amount of herbicide that reduced yields of Crystal and B5128. Similar or even larger differences exist in corn. Mindo has proved particularly susceptible among oats varieties.

The response of crops to 2,4-D is known to be affected by environment and it may be difficult in many field trials to separate environmental factors

from those of genetic origin. Recently, however, a thesis carried out in Minnesota has shown that varietal response in flax is genetically controlled and can be transmitted according to the laws of heredity. Furthermore, progenies of flax sprayed each year through four generations and progenies of flax never sprayed have been maintained at University Farm. Spraying both progenies with 2,4-D in the test year has shown no visible change in plant characters due to this continued treatment nor has the sprayed progeny shown any accumulated tolerance or susceptibility to the herbicide.

Since it has been demonstrated that varietal response is genetically controlled and since it has not been modified by continued spraying in our tests, Dr. J. O. Culbertson, who is in charge of flax investigations in the United States, and I have cooperated in a comprehensive test of flax varieties and strains this year. Seven varieties and sixteen numbered strains that had been selected for inclusion in a uniform regional nursery trial were used. Each selection was sown in rod-row plots replicated three times. Half of each plot was sprayed and the other was left unsprayed. Weeds were controlled on all plots by hand cultivation so that the effect of the herbicide on the flax could be measured. Since MCP has been found to be preferable to 2,4-D for flax, the amine salt of this formulation was used at 4 oz. per acre. Comparative data for the sprayed and unsprayed plot of each selection were obtained for date of first bloom, date of full bloom, height, lodging, pasmo, weight per bushel, and yield of flax seed. Just as in the case of yield trials, more than a single year's data are needed before it is possible to determine the effect of an herbicide on a flax variety. It is planned to continue these trials on all breeding material considered promising enough for test. The response of each strain will be considered in the breeding program to be of similar importance with other agronomic, disease, and quality characters. When a new variety is released, its reaction to MCP will be included as an integral part of its description.

It is also planned to begin similar trials on breeding material for oats and barley.

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FORMULATION PROBLEMS WITH HERBICIDAL CHEMICALS

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Abstract

The advent of organic herbicides resulted in an increase in the complexity of problems in formulating of herbicidal chemicals. The past experience gained in dealing with these problems points the way toward the deriving of fundamental relationships and the utilization of certain physical and mathematical concepts in solving future problems.

The selection of a derivative that will possess maximum activity and still be tractable enough to deal with in spraying operation can be made on the basis of physical and chemical characteristics of the compound coupled with the consideration of its activity as expressed by chemical potential or partial molar potential and the bond energies of the points of attack by destroying forces.

Solvents for formulation are chosen on the well known principle of organic chemistry that materials are most soluble in those substances which resemble them most closely in structure. Similarly the use of non volatile solvent of diluents can appreciably extend the residual life of volatile active ingredients.

Considerably more detailed investigation of special nature will have to be undertaken to provide the information where with the solution of additional formulation problems may be solved. At present there are available some powerful tools in the forms of kinetic and thermodynamic considerations that permits rather exacting deductions of the necessary requirements of characteristics of the chemical and formulation. If these were supplemented with some data, exacting solution to many of the problems present and future could be obtained.

AN INEXPENSIVE CONTROLLED ENVIRONMENT CHAMBER FOR HERBICIDE RESEARCH

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Abstract

Several types of environment chambers have been described for physiological research ranging in size from the small cabinet of Granfield and Zinc (1937) to the converted cold storage vault of Antoginnini (1951) and the basement room used by Hamner (1944). Several combinations of hygroscopic chemicals and atomizers were used to maintain the desired relative humidity. Temperature control was achieved with refrigeration and heat.

Our controlled environment chamber consists essentially of two parts: (1) a refrigerator for cooling and dehumidification, and (2) a plant cabinet fitted with lights and automatic temperature and humidity control apparatus. Cooling and dehumidification are effected by circulating room air around the cooling element of the refrigerator inside a baffled metal jacket sealed to the cooling element. Air temperatures inside this jacket are reduced as much as 40 degrees Fahrenheit. Circulation of air around the cooling element and through the plant chamber is accomplished with a 10-inch fan contained within the air system. Complete air exchange within the plant chamber is accomplished in 2.2 to 5.5 minutes, depending upon the resistance employed in the fan circuit. All air entering the plant chamber passes through a heater consisting of six 100-watt incandescent bulbs shielded with a metal hood. This heater is activated by a gas-bellows type temperature switch located in the plant chamber. Temperatures ranging from 75+1 to 90+1 degrees Fahrenheit can be maintained provided the outside temperature does not exceed 80 degrees.

Humidification of the air within the plant chamber is accomplished with a system similar to that described by Henderson and Hunt (1951). Air within the plant

chamber is circulated through an atomized water spray controlled by a humidistat and solenoid valve. A constant relative humidity between 25±2 and 90±4 percent can be maintained.

Illumination is supplied by forty 40-watt 4500 degree white fluorescent tubes mounted in two banks of 20 tubes each. Aluminium foil resting on the tubes serves as a reflector and increases the illumination approximately 200 foot-candles at plant level. Ballasts for the fluorescent tubes are mounted on a panel outside the chamber to reduce the heating effects. Full illumination provides 1,200 to 1,800 foot-candles, and 850 to 1,000 foot-candles are obtained when half the tubes are lighted.

The plant chamber is of wooden frame construction 20 inches high, 111 inches long and 36 inches wide inside. Double walls and ceiling panels of clear plastic sheeting permit observation of plants and instruments contained in the chamber and provide insulation against outside temperatures. Removable wall panels permit access to the chamber to effect any treatment.

This system of environment control can be constructed at a cost of approximately $250 for materials. The major items of expense are the fluorescent fixtures and the humidity system. Critical control of temperature and humidity is afforded within reasonable limits. Floor space in the plant chamber is sufficient for factorial experiments. Should the plant chamber become contanimated, it can be renovated or replaced at small additional expense.

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A TECHNIQUE FOR STUDYING ANNUAL WEED CONTROL IN FLAX

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Brookings, South Dakota

The purposes of the investigation were to study: (1) effects of several weedicides on flax yields, (2) effect of an annual weed infestation on flax yields, (3) effects of herbicides on yields of weedy flax, (4) effectiveness of chemicals for controlling annual weeds and (5) the differences between experimental results and field application. Since only a limited amount of hand labor was available, it was necessary to plan the study so that most of the work could be done with the machinery on hand.

Plans. It was decided that weedfree flax should be used to study the effects of weedicides of flax yields while flax infested with annual weeds should be used for the other objectives. Weedfree flax was to be seeded in rows similar to small grain nursery plots so that volunteer weeds could be removed with a cultivator. However, it was felt that weedy flax should be seeded like it is usually seeded in the field in order to get the normal competition from the weeds. Therefore, weedy flax was to be seeded in rows with a 6-inch spacing between rows. It was decided that objectives 2,3 and 4 would be studied in two experiments--one would be infested with either broadleaved weeds or grassy weeds. A mixed population of weed seeds could then be broadcast with a tractor mounted seeder over the entire area of one experiment (Exp. II), but individual plots would have to be seeded with smaller equipment in the other (Exp. III). The comparison between experimental results and field application was to be obtained by comparing results from a fourth experiment with those of the first three.

Plot size was also governed to some extent by the machinery on hand. Weedfree plots would be four rows wide and 15 feet long. Forty treatments, including untreated check, eleven chemicals at 2 or 3 rates and mixtures of chemicals would be applied to the middle two rows and these same rows would be harvested for yield. The outside rows would serve as guard rows while one and one-half feet would be trimmed from each end of the plot before harvest to remove border effect. Weedy plots would be five feet wide and fifteen feet long, separated by 3-ft. alleys. This would make it possible to cultivate alleys with a Ford tractor after wheels were set out to straddle the plot. After one and one-half feet were trimmed off each end, harvesting would be done from middle four rows twelve feet long. Thirty treatments including weedfree check, untreated weedy check and most of the chemical treatments used in Experiment I would be applied to plots in Experiment II; whereas, only ten treatments, including weedfree check, untreated broadleaved weedy check, grassy weed check and some chemical treatments used in Experiment I would be applied to plots in Experiment III.

Methods. The perimeter of Experiment II and each plot of Experiment III were staked out during the fall of 1952. A mixture of weed seeds was broadcast over the entire area of Experiment II and broadleaved weed seeds were broadcast on some plots of Experiment III while grassy weed seeds were seeded on others. A 12-foot broadcast seeder (resembles a grain drill but has no spouts or disks) mounted on a Ford tractor was used to seed the weed seeds on Experiment II. The same seeder was used in Experiment III, but only the middle five feet were seeding. Each plot was seeded individually. All weed seeds were disked under shortly before freeze-up.

In the spring of 1953, stakes were spaced at eight-foot intervals along the ends of the experiments. Two stakes at opposite ends were set at the middle of each row of plots (1 plot on each of 6 ranges). The wheels of a Ford tractor had been set apart so that it straddled the five-foot plot. The tractor and drill used for seeding, straddled the stake at one end and traveled in a straight line to straddle the stake at the opposite end of the experiment. For the 5- x 15-foot plots, three flutes were closed off at each end of the eight-foot drill so that only ten flutes were seeding a 5-foot swath. For the four-row plots, alternating

flutes were closed and the rate of seeding doubled. Each trip across the field seeded eight rows spaced one foot apart. It was necessary to seed one way and come back empty in order to make row spacing come out right.

When the flax came up it was growing in rows 1-foot apart in Experiment I and in 5-foot strips separated by 3-foot alleys in Experiments II and III. Stakes were then measured in at each side of the experiments. The first stake on each side was placed seventeen feet from the end and the others at nineteen-foot intervals. A 4-foot duckfoot cultivator mounted on a Pony Massey Harris tractor straddled the stake at one side and traveled in a straight line to the stake at the opposite side. It cut a four-foot swath across the rows and strips of flax dividing the study into 15-foot ranges. Thus 5- x 15-foot plots were separated from adjacent plots in the same range by a 3-foot alley and from plots in the adjoining range by a 4-foot alley.

These alleys were cultivated and kept weedfree. The 4-foot alleys were cultivated with the Massey Harris tractor and cultivator, but the 3-foot alleys were cultivated with a Ford tractor and an 8-foot mounted field cultivator. Wheels on the tractor were again set out so that they would straddle the 5-foot plots. Three shanks were left on each end of the cultivator, but the middle shanks were removed. Thus a 1½-foot swath was cultivated on each side of the plot. The weedfree plots were cultivated with a specially built cultivator mounted on a model G Allis Chalmers tractor. Hand weeding was done in one weedfree plot of each replicate of Experiments II and III, and the volunteer broadleaved weeds were removed by hand from plots in Experiment III that were seeded to grassy weeds and volunteer grassy weeds were pulled out of plots seeded with broadleaved weeds.

The spraying was done with a sprayer built on bicycle wheels. One nozzle was used to spray the middle two rows of the 4-row plots, but three nozzles spaced twenty inches apart were used to spray the entire area in the 5- x 15-foot plots. This sprayer is described in Weeds Volume 1, Number 4, Pages 329-337. The treatments were applied when flax was 3 inches tall, foxtail 1 inch tall and broadleaved weeds had just emerged.

At harvest time 1½ feet were trimmed off each end of each plot leaving a twelve foot plot. The trimming was done with a National mower equipped with a 3-foot sickle bar and the material cut off was removed. Weed samples were cut by hand. The weed sample was taken from the three 6-inch spacings that separated the middle four rows in the 5- x 15-foot plots. Each sample was taken from a 1½- x 12-foot area.

The flax was harvested with a National mower equipped with a special collecting device attached to the 2-foot sickle. The collecting device was a tin hopper mounted behind the sickle bar into which the flax fell after being cut. The hopper contained two compartments and was originally designed for cutting two rows spaced one foot apart, but worked very satisfactorily for cutting four rows spaced six inches apart. At the end of the plot the flax was removed from the hopper and placed in an open stove pipe which when compressed made it easy to insert the flax into a 35-lb. paper sack that had previously been numbered and laid beside the plot. Four men working on this crew could cut and sack about 50 plots an hour.

Sacks of flax and sacks of weeds were then deposited in a corn dryer and allowed to dry for about one week at 85°-95°. They contained about 10 per cent moisture when taken out of the dryer. Dried weed samples were weighed and the yield per acre calculated. Flax samples were also weighed. They were then threshed and cleaned. The weight of seed was subtracted from total weight to determine weight of the straw. Yield of straw and of seed per acre were then calculated.

Weed yields give means of evaluating the herbicidal activity but perhaps should be taken about two weeks before harvest in order to give a more accurate evaluation. Some weeds, especially foxtail, germinate late in the season after the effect of the chemical has dissipated and after the flax is near maturity. Although they probably have little effect on flax yield they do increase the yield of weeds.

A few of the data are shown in Table 1 to illustrate the type of data obtained in 1953. In previous years, weed yields have been much higher, but good stands of flax were able to offer considerable competition this year.

Table 1. Effect of herbicides on yield of flax and annual weeds (1953)

Exp. No.	Weeds	Chemical	Flax bu/A	Brdlvd weed #/A	Grassy weed #/A
I	none	none	25.0	----	----
I	none	2,4-D 1/4#/A	21.8	----	----
I	none	MCP 1/4 #/A	23.8	----	----
I	none	TCA 5 #/A	22.5	----	----
II	none	none	22.5	----	----
II	mixed	none	19.3	171	557
II	mixed	2,4-D-1/4#/A	20.2	64	398
II	mixed	MCP-1/4#/A	18.3	43	468
II	mixed	2,4-D-1/4-TCA-5	18.0	43	197
II	mixed	MCP-1/4-TCA5	18.8	16	174
III	broad	none	19.4	173	----
III	broad	2,4-D 1/4#/A	18.6	32	----
III	broad	MCP-1/4#/A	22.3	64	----
III	grassy	none	18.0	----	792
III	grassy	TCA-5 #/A	20.7	----	259
IV	mixed	none	18.7		
IV	mixed	2,4-D-1/4#/A	23.1		
IV	mixed	MCP-1/4 #/A	23.8		
IV	mixed	TCA-5 #/A	19.1		
IV	mixed	MCP-1/4-TCA-5	19.7		

WEED SAMPLING TECHNIQUES IN PASTURES

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Abstract

Introduction

Of first importance in any experiment is to locate a representative area. In addition to being representative, it is important that the area chosen for research be as uniform as possible. Uniformity of experimental material reduces experimental error much more rapidly than increased replication.

Generalizations about Sampling

Criteria for acceptable sampling are:

1. Samples should be representative.
2. Sampling should be designed to be accurate and efficient.
3. Unbiased estimates of variance, as well as the mean, should be furnished.

In general the smaller the sample unit the more information obtained per unit of area. When the notes to be taken in a sample are time consuming then the small sample unit becomes increasingly more efficient per unit of area.

Long, narrow samples, in general, have been somewhat more efficient than square samples.

Sampling Methods

Visual estimation method. Where only large differences are important, visual estimates may be sufficient. Such estimates of vegetation are more reliable when taken on pure stands or where the species in question are visually prominent. Reliability of visual estimates is increased if those of three or more workers, estimating independently, are averaged together.

Objective methods. Objective methods, such as actual counts of plants, harvesting and weighing, occurrence or non-occurrence (as in line interception or point methods), are useful if species of interest are covered up by other species or if in heterogeneous mixture, especially if small differences are important.

Relatively large sized samples give more reliable estimates per sample, but less information per unit of area. If species of interest are sparse, a relatively larger sized sample is necessary for equal precision than if the species are in dense stands. With perennial weed species trends in population sometimes may be better followed through a period of years if sample areas are fixed.

In addition to actual counting by species or harvesting and weighing of plants in frames, there are two other important methods of sampling. They are the interception method and the point method.

The line interception method consists of noting the occurrence of species along a line of a given length. Usually, in this method, the occurrence of species is measured as the distance occupied by the basal portion of the plants situated along the line. The line interception method may also be used to estimate cover by measuring the canopy of larger plants intercepted by the line.

The equipment for the point method usually consists of a frame with guides through which are inserted long, slender, steel shafts. These shafts are pushed downward through the vegetation and the species of the herbage touched by each point is noted. This method gives a quick estimate of ground cover, and from the data obtained the percentage composition can be derived.

Short of actual grazing trials, probably some adaptation of the cage method is most frequently used for sampling production in pastures. Forage eaten is often estimated by determining the difference in weight of forage clipped from an area which had been caged (protected) from that of an uncaged (grazed) area. More precise measurement results when the caged and uncaged areas are selected as similar at the beginning of the grazing period.

Pasture weed control usually entails the continuating of the experiment for a number of years. If sampling by clipping or cutting takes a large portion of the treatment plot, weed control treatment effects can be readily up-set by the removal of seed producing plants and the reduction in vigor of perennial weeds which may accompany such cutting treatments.

WEED CONTROL EVALUATION IN WHEAT

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Abstract

A critical comparison of various criteria for evaluating weed control in wheat fields has not been undertaken. However, several methods of evaluation have been used during the past six years and certain merits and weaknesses of the methods have been found. It is intended to point out here some of the characteristics of the methods used.

Many weed species are not readily killed by growth regulator type herbicides such as 2,4-D. The weed plants may be suppressed by the herbicide and their competitive ability greatly reduced, but many of the plants remain alive throughout most of the growing season. Weed plant counts have been used as a criterion of herbicidal effect but these fail to reflect the size and vigor of the plants, therefore, the weed condition is not properly described.

Control ratings using a range of one to five or more to describe the weed condition provides a broad general evaluation of the weed stands. This method does not permit the distinction of small differences in control effectiveness. The method is rapid and fairly reproducible. It is desirable to have the plots rated by three or four people.

Plant coverage based on estimates of several small areas within a plot has been found very promising as an evaluation method. A frame with inside measurements of 5 x 60 inches, subdivided into five 12 inch long sections is placed between drill rows. The weed coverage is estimated in each section. Four locations per plot are estimated making a total of 20 estimates on which to base the plot coverage value. The value of the small area is in agreement and reproducibility by different workers or over a period of time. Estimates of several small areas tend to smooth out variations among the individual areas. The method was developed and is used extensively by ecologists for evaluating plant vegetative cover. The method is reasonably rapid. The weed plant vigor as well as presence are evaluated by this method. This method is recommended for further critical study.

Wheat yield is used as an evaluation of weed control and to determine the effects of the herbicide on the wheat plant. A correlation does not always exist between weed control and yield. Economically yield is a most important criterion. The reliable determination of wheat yield involves the use of an

efficient experimental design, appropriate plot size and reliable sampling. The experimental design should provide an efficient estimate of random variation to permit precision comparisons and to allow for probability statements. Replication of treatments is essential and four to eight replicates are recommended. If large numbers of treatments are needed, the use of incomplete block designs are recommended. Sampling of plots for yield determinations should constitute 5 to 10 per cent of the plot area. (Contribution of Washington State Agricultural Experiment Station).

EXPERIMENTAL TECHNIQUES FOR CHEMICAL WEED CONTROL WORK

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Abstract

Statistical methods are not only useful in testing the significance of data, but also, provide a means for extracting a maximum amount of information from an experiment by careful planning with the objectives of the investigation clearly in mind. By these methods it is possible to assign the treatments so that the most important comparisons will be measured with the most precision.

Factorial experiments seem to be particularly adaptable to herbicide work since it is usually desirable to include several variables. Steps in designing tests are enumerated with a particular emphasis being placed on factorial experiments. A split-plot designed for a particular factorial is outlined.

Little information has accumulated on the optimum plot size, plot shape, or number of replications. However, some factors which should be considered are presented.

There has been some misunderstanding on how to treat factorial experiments in the greenhouse, particularly in regard to differences between houses and a comparison of replication in each house. An attempt is made to clarify these problems.

In weed control experiments it is usually necessary to include check or untreated plots. These plots may cause trouble in the analysis of split-plot designs. A method of surmounting this problem is presented.

The kind of observations to be made depends on the nature of the investigation. Certain types of observations are best for answering each particular question. Several types of observations are enumerated with some of the advantages and disadvantages of each.

In most cases, data are analyzed following the analysis of variance procedure or some similar modifications depending on the particular kind of observations used. In many cases transformations are desirable in improving the suitability of the data for analysis of variance. The adaptation of these transformations to particular types of data is discussed.

It is hoped that the principles reviewed in this paper will aid weed control investigators in improving their efficiency of obtaining information.

PRESENTATION OF AWARDS

A. Industry Awards for Oustanding Weed Control Work. Remarks by W. P. MacDonald, F. H. Peavy and Company, (Minneapolis, Minnesota).

Extension Worker Award

Benj. H. Schaub. Mr. Schaub is county extension agent for Brown County at Aberdeen, South Dakota. He organized a weed control program in his county prior to the advent of systemic selective sprays. A county appropriation to continue an effective program was obtained by petition. The strength in this program is derived from 113 weed committeemen locally elected. At present all of the noxious weeds on the highways of the county are under control. One-half of the leafy spurge in the county is under control and nearly 100% of the perennial peppergrass. Seventy-two percent of the Brown County farmers now employ some form of weed control. Mr. Schaub is the dean of South Dakota county agents with twenty-eight years of service.

Regulatory Worker Award

J. H. Minks. Mr. Minks is county seed and weed inspector for Blue Earth County, Mankato, Minnesota. He has been chief weed official of Blue Earth County for the past eight years during which time he has built up an excellent weed control program. His annual reports indicate that he thinks of crops in terms of the kind of weed control they effect. For example, he is enthusiastic about alfalfa for the reason that it provides excellent control of Canada thistle, their worst weed. Sow thistle has been nearly eliminated from the county and field bindweed now is confined to five farms. All leafy spurge has been treated annually for five successive years. During the past year Blue Earth County had a weed inspector in every township, village and city. Mr. Minks conducts a one-day school annually for his inspectors. Every inspector is provided with a map showing the location of all noxious weed patches in the county. During the past year his county used over one hundred thousand pounds of heavy chemicals. It is estimated that more than forty-four thousand acres were sprayed with 2,4-D by the five hundred forty-six power sprayers in the county. In a large part, Mr. Minks attributes his fine program to the Board of County Commissioners, township boards, his county agent and Blue Earth County citizens in general.

B. Honorary Membership Awards. Remarks by G. F. Warren, Purdue University, Lafayette, Indiana.

After careful consideration the committee decided that there were two individuals who have done outstanding work in weed control that we would like especially to honor at this time. Both men have made real contributions in their respective areas and have set the highest standards, not only in their work, but in everyday living.

George M. Briggs. George Briggs grew up on a farm in Minnesota and received his education in that State, graduating from the University of Minnesota in 1916. It was in that year that he took a job as County Agricultural Extension Agent in Burnett County, Wisconsin. This was the start of an illustrious career as an extension worker.

He soon moved to the University of Wisconsin

as Assistant Professor of Agronomy and Assistant State Agricultural Extension Leader. He advanced in turn to Associate Professor and Professor of Agronomy.

George has taken an active part in the North Central Weed Control Conference having served on numerous committees and as director for three years. In our meetings he has helped to keep our thinking and actions on a sound and practical basis.

It is no exaggeration to say that George Briggs is the faculty member of the University of Wisconsin who is best known to farmers throughout the state. Those who have traveled with him marvel at his acquaintanceship for there is not a meeting place or crossroads store in the entire state that he cannot enter and greet many of those present by their first names. When George meets with a group of farmers he is not an outside speaker, he is one of them. They listen to him and they understand him.

Since his early experience as a County Agent he has had a natural dislike of weeds. For years and even decades before the modern era of weed control he was campaigning for weed-free seed and feed, for weed eradication and for the observance of regulations designed to limit the spread of weeds. In a day when weed control was in its infancy he recognized this pest for what it is. He has conducted a one man campaign to make farmers aware of the weed menace and to offer them the best control measures available. He supplied leadership when there was none. He gave recommendations when there were few to give, and he continues to inspire all those with whom he works. Clearly the cause of weed control has a dedicated and devoted worker in George Briggs.

Walter C. Dutton. Walter Dutton is originally from Ohio and received his B.S. degree from Ohio State University in 1912 and later his Master's from Michigan State. From the time he left Ohio, Walter has been working almost continuously with agricultural chemicals. He was a member of the Horticulture Staff at Michigan State College for 23 years where his chief interest was in disease and insect control with chemicals.

In 1936 he accepted a position with the Dow Chemical Company. He was made Director of Field Agricultural Chemicals Research in 1944 and is now Assistant Director of all Agricultural Chemicals Research.

In our Conference he has been an active participant having served for several years on the Research Committee and as Chairman of the Terminology and other committees as well as Chairman of the New Herbicides programs.

Notable as these contributions have been, there is an even more important one. When chemical weed control was just getting its big boost with 2,4-D, we needed sound thinking and leadership to avoid chaos. Walter Dutton has provided that. His sincere friendliness and sound unbiased judgment has won him the respect of all his associates. He has helped to make our Conference and the entire weed control program a sound cooperative venture in which industry works closely with public institutions. Without this fine teamwork which he fostered, we could not have made such advances as we have seen in the past ten years. We are proud of this cooperative spirit and are thankful for the guidance and the splendid example that Walter Dutton has set.

WEED CONTROL IN FALL-SOWN SMALL GRAIN

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Abstract

Of the fall-sown small grains winter barley and winter oats made up a relatively small acreage in the North Central Weed Control Conference area. A large part of the rye which is grown in North America is seeded in this area, but the acreage is small when compared with approximately 50 million acres normally seeded to winter wheat in the United States. Of this acreage, some 25 million is grown in the North Central Region. If we may extend the boundaries of the region southward to include Texas, we find that Texas, Oklahoma, Kansas, and Nebraska plant nearly one-half of the total seeded acreage of winter wheat. To further define the area under primary discussion it may be noted that, with the exception of the above mentioned four states, only Ohio, Indiana, Illinois, Missouri, Colorado, Montana, and Washington normally seed more than one million acres of winter wheat. Kansas normally seeds approximately 14 million acres or about 1/4 of the total United States acreage. Because of the over-shadowing importance of wheat in the fall-sown small grain group, most of this discussion will be concerned with weed control in this crop.

Upon examination of the acreages which are seeded in Kansas, it becomes evident that production is largely on units containing a great number of acres rather than on the smaller diversified farms which are common in the states to the east of the great wheat producing area. For example in 1952, three Kansas counties seeded more than 1,200,000 acres of wheat and harvested over 28,200,000 bushels of grain. In all three of these counties well over 50% of the total land area was seeded to wheat and in excess of 80% of the total number of harvested acres of all crops was seeded to wheat. This same type of farming is, of course, common in the large spring wheat producing areas. The importance of other grain producing states should not be overlooked but it is on these large acreages that I am best acquainted with weed control in winter wheat.

When weed control in crops such as wheat is mentioned, most people associated with the crop and with weed control problems think first of control with 2,4-D. This chemical is extremely important from the standpoint of controlling weeds in the crop but examination of the data obtained over the past several years will show that the use of 2,4-D on fall-sown cereals, particularly wheat, has never reached the importance that it has for use on certain other crops, specifically spring-sown wheat. I believe there are a number of basic reasons for this apparent lack of acceptance by the winter wheat growers. First of all, the problems associated with winter wheat production are quite different from those in spring wheat farming. If we assume an average distribution of rainfall, we find that the wheat seeded in the fall of the year usually will make sufficient growth to bring about some tillering of the wheat in the fall of the year. Although winter snows and other forms of

precipitation over the great plains, particularly the southern great plains, are not generally heavy, there is usually enough moisture to promote a rather rapid spring growth of a well established wheat plant. If such a condition occurs, the wheat will normally make sufficient growth in the late winter and early spring to overcome most weeds merely by plant competition. It is only in those years that are characterized by dry soil in the fall of the year followed by lack of moisture in the winter and then perhaps spring rains which tend to promote the growth of weeds as well as wheat that we normally expect a serious weed infestation in our winter wheat fields.

In looking over the past seven years of winter wheat production, we find that in two of those years conditions existed which resulted in serious weed infestations. Probably the greatest infestation occurred in 1948, and as you all know, that was not long after the beginning of widespread use of 2,4-D. In 1948 Kansas wheat producers were not well acquainted with 2,4-D. There were an insufficient number of farmer-owned sprayers and an insufficient number of competent commercial operators. Nevertheless, approximately 750,000 acres were sprayed in Kansas in 1948. This is a rather small percentage of the 13 or 14 million acres which were seeded.

In 1949, similar conditions existed in that moisture was deficient in the fall of 1948 and the wheat did not make a normal fall growth. The spring of 1949 saw a tremendous influx of sprayers of various types, both ground and aerial, moving into Kansas and, in spite of low yields, over one million acres of Kansas wheat were sprayed. In contrast, very few acres were treated with 2,4-D in 1950. Although the yields were not high, the wheat made sufficient growth in the spring to eliminate most of the weed trouble by competition.

The crop produced in Kansas in 1951 was one of the smallest since the drought years of the 1930's. Weeds were again somewhat of a problem but under different circumstances than occurred in 1948 and 1949. In those two years most of the trouble had been caused by lack of emergence and growth in the fall of the preceding year. In 1951 the greatest difficulty was due to the fact that excessively heavy rains occurred near the harvest season thus preventing harvest operations at the normal time. The abundance of moisture was favorable for late emergence of weeds and many fields became weedy at the time wheat was ripe. Considerable acreage was sprayed late in the season of 1951.

In 1952 Kansas produced the largest crop on record. The stand of wheat and wheat growth was such that during the entire season, I was unable to locate even one field which had been treated for weed control. I am sure that such a field must have existed, but the aerial and ground equipment sprayers had a lean season.

The 1953 wheat crop was produced under adverse conditions. The fall of 1952 was similar to that experienced in 1947. Most of the wheat was planted in dry soil and emergence did not occur until late in the winter or in some cases early spring. Conditions appeared to be ideal for invasion by numerous species of annual weeds. Commercial spray operators and chemical companies alike, anticipated one of the biggest volumes of business that they had ever experienced in Kansas. Unfortunately for both them and the Kansas farmers such a condition did not develop. I do not mean to insinuate that wheat farmers wanted trouble with weeds, but rather they would have welcomed the rains necessary to cause weed growth. Extreme drought conditions prevailed over much of the winter wheat area during the winter and spring of 1953. Had the average amount of precipitation been received, there would have, without question, been a serious weed problem in much of the area; but also without question properly timed rains would have greatly increased the crop production.

Let us look at the research work which has been done concerning the effect of 2,4-D on winter wheat and the use of this chemical for controlling weeds in the crop. In going through the reports of the Research Committee of this conference, it may be noted that in 1947 three abstracts were submitted concerning weed control in fall-sown small grains. In 1948 this number jumped to ten. These abstracts were received from Ohio, Kansas, Oklahoma, Nebraska, Illinois, and a region somewhat out of the normal winter wheat producing area, namely Alberta, Canada. In 1949 sixteen abstracts were submitted, followed in 1950 by nine; and in 1951 the number had again dropped to three. This is in considerable contrast to the amount of research work reported on other crops such as corn, or, more closely related, spring-sown small grains.

I believe that this seemingly small amount of research work may be attributed to at least two factors. First, as mentioned, the lack of regularity with which weed infestations occur, and, second, in general, winter wheat has proven to be one of the most tolerant of the cereal crops to applications of 2,4-D. Of the various reports on the use of 2,4-D on winter wheat only a few have told of serious reduction in yields at rates of 2,4-D necessary for normal weed control.

It is recognized that certain stages of growth are to be regarded as danger periods. Most research workers are in agreement that fall applications of 2,4-D on winter wheat often will reduce seriously the yield of the crop. A discussion of fall applications of 2,4-D will nearly always bring up the question as to the necessity or desirability of making applications of this chemical in the fall. I would point out that with the tremendous wheat acreages in the Great Plains we have, unfortunately, a large acreage of field bindweed. It has been found that this serious weed pest can be rather satisfactorily controlled by fall applications of 2,4-D in those seasons when sufficient moisture is received to provide a vigorous fall growth of bindweed. Many wheat farmers would find it advantageous to treat their bindweed infested land in the fall of the year without interrupting their wheat production, however, such treatment often results in serious damage to the wheat crop.

A second danger period has been shown to exist during the boot and early heading stages of growth. The reports from the various research workers indicate that this stage of development is not so highly critical as is the fall stage of growth. Damage from 2,4-D occurs frequently enough that possible yield reductions must be considered before the chemical is applied during the boot and heading stages of development. Except for these stages of growth, it is generally believed that winter wheat will ordinarily tolerate a sufficient amount of 2,4-D to control most annual weeds which normally infest the crop.

In addition to these reports of research work, field observations have shown that an additional period of crop damage may exist during the stiff dough

stage of wheat development. It has been assumed that after the grain reaches the soft dough stage little damage would be encountered from the use of 2,4-D on wheat or any of the other cereal crops. However, in 1949 and again in 1951, there were some reports that applications of 2,4-D during this late stage of development resulted in an elongation of the uppermost node of the wheat plant. This node became weakened and in some cases a separation occurred in the node, and the wheat lodged. This damage has not been, to my knowledge, reproduced in experimental plots, but there seems little question but that 2,4-D caused the damage in commercially sprayed fields.

In addition to studying the effect of 2,4-D on the yield of wheat numerous workers have reported the effect of this chemical on germination, test weight, protein content, and milling and baking qualities of grain produced from plots which had been treated with 2,4-D. At rates normally used for weed control purposes little or no effect on germination has been noted, however, in 1950 there was one report of reduced germination of wheat from plots treated with one-half pound or more of 2,4-D. The effect on test weight has been negligible. Several published reports have indicated that applications of 2,4-D on wheat have increased the protein content of the grain. However, in most cases, the increase in protein was accompanied by a decrease in yield so that the total protein per acre was not significantly affected. Applications of 2,4-D have not been reported to affect appreciably the milling or baking qualities of winter wheat.

Numerous chemicals other than 2,4-D have been applied to winter wheat and other small grains. To date none of these chemicals has been more effective in controlling the weeds without doing considerable damage to the wheat. 2,4,5-T and MCP have been used and results obtained from these chemicals have been similar to those obtained from the use of 2,4-D.

The use of chemicals for weed control in winter wheat may be summarized by saying that the crop may be treated in the spring of the year after it is fully tillered and before it reaches the boot stage with 1/4 to 1/2 pound of 2,4-D acid equivalent per acre with little danger of serious reductions in yields. If the application is delayed until after the wheat reached the boot stage, there may be some danger of crop damage until such time as the wheat grain has developed into the soft dough stage. During the soft dough stage the plant usually will tolerate a sufficient amount of chemical to kill susceptible weeds which are present. Exceptions to this statement have been noted. From the standpoint of economical weed control, it is usually more desirable to apply treatments during the earlier stages of growth rather than wait until the soft dough stage because of the greater difficulty of getting satisfactory control of the large weeds at the latter stage of growth, also earlier elimination of weeds reduces their competition effects.

If the weed control problems in winter wheat could be limited to those presented by weeds which are susceptible to 2,4-D, the situation would be greatly simplified. Unfortunately, however, there are numerous species which are completely resistant to 2,4-D or which are semi-tolerant to the chemical and require dosages in excess of those believed safe for application to a crop. This latter group includes such weeds as wild onion, particularly serious in the eastern part of the region, and wild buckwheat which is commonly found in much of the winter wheat area. Some degree of control of both these weed pests can be obtained with the proper use of 2,4-D. However, complete control is usually not obtained with single applications.

One of the most serious weed pests in winter wheat production is the group of annual and winter-annual weedy grasses. Chief offenders of this group, at least in the western sections, are the wild bromes and goatgrass (Aegilops spp.). Goatgrass is particularly serious in some areas where continuous wheat farming is practiced. A crop rotation system such as one year of grain sorghum followed by one year of summer fallow and then returning the land to wheat will usually eliminate nearly all of the goatgrass. To those of you who live east of central Kansas, summer fallowing may sound like an expensive way to control a weedy grass. However, in western Kansas such a rotation is regarded as a sound farming practice. It is, however, difficult to use a rotation on any large scale when one considers that over 80% of the crop land may be seeded to wheat.

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WEED CONTROL IN SOYBEANS

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Abstract

Weeds have become the greatest hazards to good yields of soybeans in much of our soybean belt. Although great progress has been made in fertilization, new varieties and cultural practices, these advancements have not fully expressed themselves in many fields of soybeans because they have been offset by heavy weed growth. Although chemical weed control in soybeans is promising, our best weed control program for soybeans is still accomplished by crop rotations, early seedbed preparation combined with delayed planting and good cultivation. Crop rotations are important in controlling weeds in soybeans because they help prevent certain types of weeds from building up or from increasing so rapidly. Growing continuous soybeans under poor management is one of the best ways to thoroughly infest a farm with annual weeds. Soybeans are not entirely to blame for this situation but poor management of the crop plus the combine, which is one of the most efficient means that we have for scattering weed seeds in the field, will allow the annual weeds to build up a large supply of seed in our soil. It would appear that in many of our soybean areas the type of weed problem is changing rapidly. Grass weeds, particularly the annual grasses, are spreading much more rapidly than the broadleaved type of weeds. This is particularly true in the giant foxtail areas which now cover the greater part of the soybean belt in Illinois and western Indiana. There are probably many factors contributing to the grass weed build-up in our soils, but I think we can attribute part of it to the continued use of 2,4-D in our cornfields. By eliminating or reducing our broadleaf weed population in corn we are making conditions more favorable for the grass-type weeds and by doing so we have upset the balance of nature. If this trend continues we

will be faced with a very serious problem because we have no good chemical means for controlling grass in most of our crops. The best control for annual grass weeds in our soybean fields is undoubtedly early seedbed preparation combined with delayed planting. Giant foxtail, as well as green and yellow foxtail, germinates early in the season. In central Illinois this germination starts approximately Apil 15 and continues heavily for at least one month. Many farmers do not take advantage of this situation and prepare their seedbed around the last of April and then immediately plant soybeans. It is under these conditions that soybean fields are very apt to become thoroughly infested with foxtail. On the other hand, if the primary crop of foxtail are destroyed between April 15 and May 15, it will do a great deal toward eliminating the early competition from this weed. It is true that giant foxtail and even some of the other foxtails will germinate later on in the season, but certainly from our records the primary germination is early in the year and it is from this early germination that we get our severe competition to soybeans.

By planting soybeans early in our foxtail area while the soil is still cool we get slow germination of soybeans and a rapid germination of the giant foxtail, but by planting our soybeans the latter part of May or the first of June we not only get much less germination of foxtail but we also get very rapid germination of soybeans, frequently getting emergence in 4 days. This allows us to cultivate much sooner than we would in early planted beans which in turn gives us much better control of the seeded grass.

I believe that we should spend more time in convincing our farmers that the date of planting soybeans is not nearly so important insofar as final yield is concerned as it is for example in corn, but the rate of planting soybeans is highly important insofar as weed control is concerned. There are several other cultural developments that are helping the farmers to control grasses in soybeans which may become more important. One of these developments has been to try to prepare a rough seedbed on the surface at soybean-planting time. The thing that brought on this idea was that a very good seedbed preparation always produces the maximum germination of the annual grasses, particularly giant foxtail. Many of the farmers have turned to field cultivators that prepare a good seedbed several inches below the surface but leave the surface rough. By this method they are getting good bean germination and getting them up well in advance of the germination of the giant foxtail. It would appear that this seedbed preparation idea is good and although it does not solve our giant foxtail problem, I believe it will help materially to get soybeans off to a good start in their struggle with this annual grass.

A second cultural practice that is being used quite extensively in the annual grass area is the use of furrow openers. These furrow openers plant soybeans in a shallow trench and the farmers are using this idea to cover up the seedling foxtail after the soybeans are several inches through the ground. The use of furrow openers can only be combined with delayed planting because this method depends upon rapid germination of the soybeans so that the dirt can be thrown down in the furrow. A third cultural practice being initiated on a small scale has been to plant soybeans in 28-inch rows instead of the usual 40. We all know that soybeans once they are established do form a great deal of shade and in many areas are considered a good weed control crop for this reason. Although soybeans in 4-inch rows do eventually fill the center of the row this does not happen until later on in the season, but if the soybeans are planted in narrower rows the center of the rows will be filled sooner, as a result there will be less germination of late weeds, particularly the grass weeds. This has proved to be true in some areas and it certainly appears worthy of further investigation. Added weed control and slightly higher yields in 28-inch rows as compared to 40-inch rows could offset the cost of extra equipment needed in a small experiment. Here at the Urbana Station last year, Mr. J. W. Pendleton and I studied the yield of soybeans by different methods of planting. All of the beans were in 4-inch rows but within the row they were planted in 5, 10, 20 and 40-inch hills, as well as the regular drilling. Although we get some useful information on yields from this test we also obtained valued information about weed control. There was very definitely a trend toward less weeds in the drilled rows and most of the weeds at the end of the season were found in the soybeans planted in 40-inch hills. Although these new cultural practices are interesting and will probably develop in certain areas, our main cultural weed control in soybeans must still be accomplished by early seedbed preparation combined with delayed planting. Although chemical weed control is extremely promising in soybeans it offers limited possibilities at the present time in relieving the serious weed situation.

Pre-emergence sprays offer particular promise in soybeans because if they could be successfully used they would control this early weed growth which is the most serious to us insofar as yield reductions are concerned. Unfortunately the pre-emergence chemicals available for soybeans have only been partially successful. They appear much more promising on some of the lighter soils but on the heavy soils here in the main soybean belt the results have been quite variable. The two main chemicals being recommended for pre-emergence weed control in soybeans are dinitro and Chloro IPC. Each of these chemicals has some advantage over the other chemical but the end results are somewhat similar. The Chloro IPC has given slightly better control of the annual grass weeds but seems to be a little less effective on the general broadleaf weeds than the dinitro. Both chemicals are being recommended at rates of 6 to 8 pounds of the acid per acre as an over-all treatment. The rates are slightly lighter for some of the lighter soils. On the heavy soils here in the soybean belt this rate of application seems to be at the lighter side in order to get good weed control and yet it is on the heavy side insofar as soybean injury is concerned. In other words, we could get much better weed control if we use 10 pounds of each chemical but insofar as soybean injury is concerned the 6 to 8 pound range is probably at the upper limit. Pre-emergence chemicals have generally not been successful during short drouth periods at planting time. This has not been too serious because during these short dry periods we seldom get normal weed control. However, they have not always worked successfully under moist conditions when we do get normal weed control. This has been the most serious limitation. In a series of approximately 12 tests at the Illinois Experiment Station this year the weed control worked from approximately 95 percent to 0. These 12 tests were scattered over our state in various locations under different soil and climatic conditions. It would appear that these chemicals will not be accepted by our soybean growers on a large-scale basis until the outcome can be more nearly predicted insofar as weed control is concerned.

We do believe that these chemicals should be used by farmers on a trial basis. We think that they

will work very well on some soils in certain areas. It would appear from the results of the various experiment stations that these are probably the best chemicals available at the present time. All indications are that there may be new and better pre-emergence herbicides available. Insofar as post-emergence treatments on soybeans are concerned there are very few chemicals that can be used on the growing soybean plant without severely injuring them. One of the most promising treatments for limited areas has been 2,4-D applied when the soybeans are 4 to 8 inches tall. We would have to consider this as an emergency measure. Soybeans at this stage of growth are more tolerant to 2,4-D than at the later stages of growth. A light-rate application of 2,4-D, somewhere in the neighborhood of 1/16 pound of acid per acre, seems to have very little effect on final yield. This rate of application is sufficient to kill cockleburs, giant ragweed, and pigweed. It will also hold many of the other broadleaf weeds in check so that the competition is much less severe to the soybeans. The only area where this light-rate treatment seems feasible is in the bottomland areas where these annual broadleaved weeds are extremely serious each year and in these areas, it should only be used as an emergency measure. Again with this type of treatment, as with pre-emergence sprays, we would first advise small area treatment until the farmer sees how the treatment works in his area and how well it controls weeds. It is up to him to make the final decision as to whether he should spray his entire acreage.

The weed control problem on every farm is usually a little bit different. I think it is impossible for anyone to make broad, general recommendations that will apply over an entire soybean area. It appears that general recommendations can be made but the final recommendation is up to the individual farmer.

The other post-emergence treatment that has some possibility on soybeans is the use of the herbicide oils. These are being tested at several stations in the cotton belt on soybeans this year, and we are doing the same at the Illinois Experiment Station. It would appear that soybeans have considerable tolerance to these oils and we know from experience in the cotton belt that these oils are very good for controlling weeds in the seedling stages. Whether these oils will be of importance in soybeans cannot be determined at the present time.

If we are going to control our number one enemy in our soybean crop we cannot rely on any one method alone. Certainly cultural practices are the most important weapons that we have in our fight against weeds. Chemicals are encouraging but at present offer only limited possibilities for weed control.

WEED CONTROL IN SORGHUMS

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Abstract

Annual weeds are not as serious in sorghums as they are in many other field crops, for sorghums are usually planted late in the season after many weeds have germinated and can be destroyed by good seedbed preparation. The grain sorghums are grown in dry sections where cultivation is never delayed for long periods of time by rain. The forage type sorghums are considered one of the best competitive crops for combating weeds.

Because of the reduced wheat acreage, more combine grain sorghum plantings can be expected in the future. Most of the increased acreage will be planted with wheat drills, thereby eliminating cultivation after planting. Herbicides are being used commercially in sorghums and on a broad scale in some areas. The expected acreage increase with no control of weeds by summer cultivation may increase the demand for chemical control of weeds in this crop.

From the few reports submitted to the NCWCC on chemicals for weed control in sorghums it is very clear that 2,4-D has the greatest possibilities. MCP is usually considered less dangerous to crops than 2,4-D, but in sorghums this is not true. Actually, sorghums are more tolerant of 2,4-D than of MCP. 2,4,5-T probably is no more injurious to the crop than 2,4-D. Sorghums are more tolerant of the sodium and amine salts of 2,4-D than of the esters.

Treating sorghums at the proper stage of growth is most important. Pre-emergence sprays are not too promising because the young plants are susceptible to most of the pre-emergence chemicals. Some tests with 2,4-D look good, but too often some plants are killed before or immediately after emergence. Spraying young sorghum plants under 3 to 4 inches high may kill some plants and severely injure others. It is apparent that sorghums are susceptible to 2,4-D during the advanced stage of growth, especially at blooming time. Spraying at this time may cause sterility and lower grain yields drastically. Fortunately, sorghums are more resistant to 2,4-D at 6 to 10 inches in height, for this is the proper time to control weeds in the crop.

The most common abnormal condition that results from 2,4-D is brace root malformation. This injury is common in corn but is more pronounced in sorghums. It is easy to observe this apparent injury to the brace roots in the field on most sorghums treated with 2,4-D. One-fourth pound 2,4-D per acre may cause noticeable abnormal brace roots on some varieties. Although this morphological effect on sorghums indicates susceptibility to 2,4-D, it does not necessarily indicate close correlation with yields. Some forms of injury to the plant that can be more closely correlated with yields are dwarfed plants, late maturity, poor head exertion, and sterility. Bending of the stalks after 2,4-D treatments, which is common in corn, is rarely observed in sorghums. Brittleness associated with 2,4-D injury to corn has been reported only once on sorghums. A few stalks of susceptible varieties were observed broken off near the ground after a severe rain and wind storm that occurred a few days after 2,4-D spraying.

Results of tests for six years show varietal differences in response of sorghums to 2,4-D treatments. Varietal response may differ from year to year, and also for treatment at different stages of growth. A large number of varieties have been tested for several years in order to classify varieties as to their susceptibility to 2,4-D. Some varieties are not affected by excessive rates of 2,4-D. Most of the forage sorghum varieties are in this group. Some of the milos (combine grain varieties) may show injury under some conditions at low rates of 2,4-D. The taller growing grain sorghums (kafir) appear to fit in between the milo and forage group as far as 2,4-D is concerned.

Varietal differences among sorghums may possibly be explained by the broad genetic base of this crop. Since sorghum varieties have a narrow range of climatic adaption, it will be necessary for each state interested in this problem to check its own adapted varieties.

Variety susceptibility and effects of different rates of 2,4-D can be determined to some degree of accuracy by checking injury to the root system. By measuring the pounds of force necessary to uproot sorghum plants, great differences were found among sorghum varieties when treated with several rates of 2,4-D. For Wheatland variety (susceptible to 2,4-D) pounds of force required to pull the roots from a hill of 3 stalks were 381, 294, 230 and 162 for the check, 1/4, 1/2 and 1 lb. rates per acre, respectively. This is a difference of 58% between the check and 1 lb. per acre treatment. Dwarf Kafir, a more resistant variety, had a difference of only 12%.

The extent of root injury of sorghums is not necessarily associated with grain yields. It is apparent in grain sorghums that measuring the root injury by pulling the plants from the soil gives a better index of varietal response than measuring the grain yields.

Considerable injury by 2,4-D on sorghums has been reported from tests. However, in most cases the rates were excessive for weed control in crops, or treatments were made during stages of growth when the plants were susceptible. Like most crops, there is always some danger of injury when 2,4-D is used on sorghums. The best recommendation for use of 2,4-D for weed control in sorghums is to use 1/2 lb. or less per acre of 2,4-D (amine formulation) and apply when plants are 6 to 10 inches high.

LEVELS OF WEED INFESTATIONS AS RELATED TO YIELD LOSSES AND CONTROL PRACTICES IN CORN

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Weed infestations which can be effectively and economically eliminated by cultural practices or herbicides offer little potential hazard to crop production. Similarly the potential crop losses from extremely heavy weed growths are generally well recognized; such infestations of weeds are very often the result of a serious failure in one or more of the conventional practices of crop production. However, when the infestation consists of weed species which have survived the conventional methods of control, the remaining level of infestation may be relatively low. Under these conditions the yield reducing potential of the weed infestation must be considered in relation to the further cost of eliminating it. The residual infestations of annual grass weeds which survive cultivation and the use of 2,4-D in corn are a common and widespread example of this situation. In these experiments an attempt has been made to measure the yield losses in corn resulting from light to moderate infestations of annual grass weeds, and from these measurements to evaluate the effectiveness and economy of one or two of the known methods of controlling these residual infestations. The general procedure was to maintain plots in a weed-free condition during the growing season and to compare their yields of corn with those from plots containing weed infestations of different levels over varying periods of the growing season. Yield of weeds at maturity, expressed in pounds of dry matter per acre, was the criterion of infestation level. In all cases the weed infestations were those which remained after normal cultivations had been completed. Weed seeds were planted in the experimental areas to obtain uniform weed growth. Ninety to ninety-five percent of the infestations consisted of yellow foxtail (Setaria glauca (L), Beauv.), with a scattering of broadleaved species.

Yield reductions from different levels of weed infestation. Among the factors influencing the reduction in corn yield obtained with weed infestations are the size of the infestation, the length of time it remains in competition with the crop, the general fertility level of the soil on which the crop and weeds are growing and the moisture supply available. The effects of these factors were studied under field conditions in a series of experiments which were also used to evaluate certain pre-emergence herbicides. Split-plot designs were used in which the rates of application of herbicides were the sub-plots. Included in the rates were two check plots, one of which was cultivated conventionally, the other was cultivated and kept weed free by additional hand weeding. Additional experiments involving different periods of corn and weed competition were also conducted. The usual corn yield trial procedures were followed in all tests, using either a 2 x 10 hill plot for checked corn or two, 30 foot rows for drilled corn. Guard rows were provided in all tests. Most of the experiments were conducted in drilled corn, since this type of seeding was quite suitable for the evaluation of the pre-emergence herbicides. Plant stands and yields of corn and yields of weeds at maturity were obtained for all experiments.

The data in Table 1, summarize the results from four experiments conducted in each of four years. These results are from drilled corn except for the 1953 test. The weed infestations remained in competition with the corn during the season, and consisted of the annual grass species which survived three or four timely and effective cultivations. Ninety to ninety-five percent of the infestations consisted of yellow foxtail, with a small representation of broadleaved annuals. Infestations of the magnitude of 500 pounds per acre or less of dry material at maturity may be considered rather common in many relatively clean fields. The reductions in yields of corn averaged 6 to 8 bushels per acre and were rather constant despite considerable variation in the base yields of corn during the four year period. The experiments were conducted on Clarion-Webster, silty clay loam soils, using standard hybrids and the usual standard techniques of cultivation, and moderate fertilizer applications.

Table 1. Yield reduction due to moderate weed infestations in field corn.

Year	Number of plots	Cultivated		Cult. and Handweed	Increase due to handweeding	L.S.D.
		Weeds lb./A	Corn bu./A	Corn bu./A	bu./A	P=.05
1950	24	307	74.5	80.3	5.8	4.1
1951	60	421	63.4	71.6	8.3	1.9
1952	72	679	107.1	115.6	8.5	0.3
1953	10	1460	70.4	76.6	6.2	4.2

In the 1951 and 1952 tests, data from relatively large numbers of paired plots were available which permitted a more detailed study of the results. Comparison of the yield reductions from different levels of weed infestation within a given test indicated that as the infestations of grass weeds increased in amount, the reduction in yield of corn was less per hundred pounds of weed yield. This trend was definite in both years. However, more levels of weed infestation with larger numbers of plots would be required to establish definitely the curve of yield reduction as related to increasing levels of grass weed infestations.

In 1953, data were obtained from an herbicide trial test in which two levels of soil fertility were present in the experimental area. Examination of relatively small numbers of plots indicated a differential response of drilled corn to fertility level when grown in association with annual weeds. The weed infestation which consisted of approximately two-thirds yellow foxtail and one-third Pennsylvania smartweed, (Polygonum pennsylvanicum L.) was high and yielded 3000 pounds of dry matter per acre. The yields of weeds were practically identical at both low and high fertility levels. Corn yields from weed-free plots were reduced markedly at the low fertility level. Corn yields from weedy plots were reduced 11 and 17 bushels per acre respectively for the high and the low fertility levels, compared with the weed free plots.

The above data indicated the magnitude of yield reductions which resulted when the weed infestations were left in competition with the corn for the whole season. In 1952 and 1953 an experiment was conducted to evaluate the yield reductions occurring when the weed infestations were removed at different times during the growing season. Drilled corn was used in 1952, and checked corn, cultivated one way, was used in 1953. The yields of weeds were obtained only from those plots in which the weeds grew to maturity. However the infestations were uniform and it is assumed that the infestations which were removed during the growing season were comparable to those remaining to maturity. The results of these experiments are contained in Table 2. Significant yield reductions resulted even when the weeds were left in competition with the corn for a small part of the growing season.

Table 2. Yields of corn in bushels per acre with weeds removed at different stages of corn growth.

	1952	1953
Weeds to maturity	77.6	70.4
Weeds removed 6 weeks after corn seeded	95.8	
Weeds removed at corn tasselling date	84.4	72.7
Weeds out all season	111.1	76.6
L.S.D. P=.05	14.2	4.2
Yield of weeds at maturity, in lb./ac.	2000	1460

Economic considerations of weed control methods. Herbicide treatments designed to control small infestations of weeds should be economically practical if they are to gain widespread use. The cost of eliminating these light infestations should be largely covered by the resulting increases in crop yield, although some of the cost might well be assessed against other crops in the rotation. With the above data as a basis, the practicability of several herbicide treatments may be evaluated. In Table 3 are presented cost estimates for two of the more promising methods of controlling annual grass weeds in corn. The cost figures were obtained by using the following cost schedule: shovel cultivation, $1.25 per acre; spray application $75 per acre; 2,4-D ester $1.50 per pound of acid; Dow Premerge $1.75 per pound active ingredient. The net cost per acre was figured by subtracting the cost of one shovel cultivation from the cost of the herbicide application, since these treatments usually permit a delay in beginning of cultivation, which results in one less cultivation. No estimates of weed control, crop yield increase and net gains were calculated from the Dow Premerge treatments, since only one year's data were available. The average yield increase of 7.2 bushels for handweeded corn indicates a probable surplus of 7-8 dollars per acre at current prices, available for the economical control of these light infestations of annual grasses. The use of 2 lb. of 2,4-D ester as pre-emergence spray for corn could be expected to give only a small increase in yield of corn or in weed control compared with the 1 lb. application. The added cost of the 2 pound per acre application would not be returned by the slight yield increase obtained.

Table 3. Cost Estimates for Weed Control Methods

Treatment	Total cost per acre*	Net cost per acre**	Average reduction in weed yield compared with cult. check	Average yield increase over cult. check	Net gain, corn at $1.25/bu.
1 lb 2,4-D ester, pre-emerg.	$2.25	$1.00	61% (3 yr. ave.)	5.0 (4 yr. ave.)	$5.25
2 lb 2,4-D ester, pre-emerg.	$3.75	$2.50	82% (3 yr. ave.)	5.5 (4 yr. ave.)	$4.37
3 lb Premerge post-emerg.	$6.00	$4.75			
3 lb. Premerge banded (14")	$2.50	$1.25			
Handweeded			100%	7.2 (4 yr. ave.)	

* cost of chemical plus cost of application.
** obtained by subtracting $1.25 the cost of one cultivation which the herbicide treatment saves.

In conclusion the following points may be noted. During a four year period, reductions in the yields of drilled and check planted corn, due to competition of relatively small infestations of foxtail were of the order of 6 - 8 bushels per acre and were fairly constant over a range of corn yields and growing conditions. Limited data indicated that the competitive effects of grass weeds were more severe on soil low in fertility, and that even when weeds were removed before corn tasselling the yield reductions were significant. Cost estimates for the use of effective herbicides for grass control indicated that minimum levels of herbicide application which give almost complete weed control may be more practical than applications heavy enough to control all the weeds.

TEMPERATURE AND HUMIDITY EFFECTS ON PRE- AND POST-EMERGENCE APPLICATIONS OF 2,4-D AND DINITROPHENOLS ON SWEET CORN

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The use of 2,4-D in post-emergence applications for the control of weeds in sweet corn plantings has become a generally accepted practice. In certain areas, pre-emergence applications of 2,4-D or dinitrophenols have likewise proven to be very valuable. While the results of these treatments have been rather favorable, there have been several instances in our own field studies, as well as in observations of treated fields in Ohio, which indicated that environmental factors, such as, temperature, soil moisture, and humidity were influencing to a marked extent the response of the sweet corn plant to these two chemicals.

This investigation was initiated in the spring of 1952 in an attempt to obtain further information on temperature-moisture relationships and time and rate of herbicide application as related to response of sweet corn grown under controlled environmental conditions. In addition, certain field studies were planned so as to obtain more information on the response of corn plants to conditions existing at the time of field study. Preliminary studies conducted in the greenhouse in 1948 had indicated the importance of temperature and soil moisture as related to crop response. A review of temperature, soil moisture, and humidity conditions existing at time of previous field studies using 2,4-D and dinitrophenols also added more information on the possible approach in obtaining additional answers to this problem. While space does not permit a review of the literature in this brief article, it is essential to point out that there are many reports which proved very valuable in planning and evaluating the results of these studies.

Results and Summary

The first phase of this discussion includes the results and conclusions based on greenhouse and laboratory studies under controlled environmental conditions. The second phase includes the results of field studies of the past two years, as well as interpretation of the effect of soil moisture, humidity, and temperature conditions prevailing during the investigations of the past seven years.

Greenhouse and laboratory. (1) Sweet corn growing at an average temperature of 61° F. was practically undamaged where the recommended rates of 2,4-D for pre-emergence, emergence, and post-emergence were applied. Three and six pound rates of DNBP applied just prior to emergence of sweet corn did not cause any visible damage to the seedlings.

Sweet corn growing at a continuous temperature of 80° F. revealed considerable damage with all rates of 2,4-D normally recommended for pre-emergence, emergence, and post-emergence applications. Three pound rates of DNBP applied just prior to emergence revealed slight damage to the corn seedlings, while the six pound rates caused considerable damage to the seedlings.

The humidity in both of the above temperature studies was maintained at 80% or above throughout

the period of study. Soil moisture was maintained at a moderate level, by means of sub-irrigation to avoid any leaching damage from over-head watering. Light intensity was practically the same for both temperature series, 600 foot candles or above.

(2) Sweet corn growing at an average temperature of 61° F was removed from this environment and placed in storages for twelve hours at temperatures of 50°, 60°, 70°, and 80°, F. prior to spraying. None of the 2,4-D sprays caused any damage to the corn seedlings.

Sweet corn growing at a continuous temperature of 80° F. was removed from this environment and placed in storages for twelve hours at temperatures of 50°, 60°, 70°, and 80° F. prior to spraying. All of the 2,4-D sprays resulted in comparable damage as if the plants had been held continuously at 80° F.

The dinitrophenol spray was not included in this series. Humidity, soil moisture, light intensity, and 2,4-D applications were the same as for Experiment (1).

(3) Sweet corn growing at an average temperature of 61° F. was removed from this environment and held at a continuous temperature of 80° F. for twelve, twenty-four, thirty-six, forty-eight, seventy-two, and ninety-six hours prior to spraying with 2,4-D. With the exception of the ninety-six hour holding period, all other sweet corn plants reacted as if they had been held at the average 61° F. temperature. There was some slight evidence of 2,4-D damage with the plants held for ninety-six hours at 80° F.

Sweet corn growing at a continous temperature of 80° F. was removed from this environment and held at a continous temperature of 60° F. for the same holding periods as mentioned above. With the exception of the sweet corn held for ninety-six hours, all the other sweet corn plants reacted as if they had been held at the 80° F. temperature. There was somewhat less damage from the 2,4-D sprays with the corn held at the lower temperature for four days.

(4) Respiration rates of the sweet corn seedlings which had been treated with the 2,4-D sprays, as well as with the three pound rate of DNBP, were always higher the day after treatment as compared with the untreated check. In one stance, where 1.0 pound of the amine salt of 2,4-D was applied at emergence, (80° F.), the respiration rate of the treated seedlings were significantly higher through a seven day period as compared with untreated seedlings. The respiration rate of the treated seedlings gradually dropped from a high of thirty percent increased rate for the first day after treatment to less than five percent higher rate above untreated seedlings by the seventh day.

Field studies. A review of local climatological data reveals that while there is a positive trend toward higher average temperatures from May 1st through August 1st, there is considerable variation possible in any five to ten day period throughout this three month period, when most corn is sprayed in central Ohio. For instance, the second week in June, 1947, revealed an average temperature of 65.6° F.; in June, 1949, 75.6° F.; and June, 1952, 78.4° F. Relative humidity and soil moisture are apt to reveal even a greater variability than temperature, even where irrigation is available.

In reviewing our field spraying of sweet corn at Columbus, there was surprisingly close agreement between average temperature preceding corn spraying and notes on visible damage to the corn. However, yield data did not reveal quite as close agreement, in some cases, as might be expected from rather consistent evidence of damage under the higher temperature conditions. This only tends to emphasize the importance of other factors in the environment as related to the possible conditioning of corn prior to spraying as well as influencing the recovery of corn plant after visible spray damage.

Without going into further detail of actual studies during the past several years, it might be best to list certain conclusions which have been reached, at least for the present, based on the results of these studies.

1. Temperature preceding (five to ten days) the time of spraying 2,4-D on sweet corn would appear to be much more important than temperatures at the time of herbicide application.

2. Relative humidity, while being of considerable importance in the pre-conditioning of corn, is probably of much greater importance at the time of spraying than the temperature at time of spraying.

3. While soil moisture would definitely contribute to the pre-conditioning of corn, temperature would still seem to be the major factor in the pre-spray period. In the post-spray period, adequate soil moisture becomes of increasing importance in the rapid recovery of the corn plant. Adequate surface soil moisture, just prior to spraying and during the early post-spray period, is usually essential for the best weed control.

The above statements would apply primarily to delayed pre-emergence, emergence, and post-emergence applications of 2,4-D to sweet corn in Ohio. If one could ignore the hazard of possible leaching of 2,4-D around the germinating corn seedling, the three statements above could apply to pre-emergence sprays at time of planting, as well.

With the dinitrophenols, temperature in the pre-spray period follows roughly the same situation as for 2,4-D. There is considerable evidence that the temperature at time of spraying is much more critical with the dinitros than with 2,4-D. Humidity at time of spraying is perhaps a little more critical with emergence and directed post-emergence sprays of dinitros than with 2,4-D. High humidities and high temperatures at time of spraying tend to minimize the selective value of the dinitros in spraying corn. Adequate soil moisture is essential for rapid recovery of the corn plant following emergence or post-emergence dinitro sprays. Surface soil moisture is also essential for best weed control with the dinitrophenols. Recovery of the corn plant following visible damage from dinitro sprays is generally much more rapid as compared with recovery period of corn damaged from 2,4-D sprays.

VARIETAL RESPONSES OF CORN TO HERBICIDES

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The fact that varieties of plants vary in their response to applications of herbicides adds one more

complicating factor to an already complex problem. It is well known that type and preparation of herbicide used, rate of application, date of application, growing conditions of the plant and possibly other factors influence the sensitivity of plants to herbicides applied for the control of weeds. If maximum returns are to follow the use of herbicides it is essential that injury to the crop be insignificant or at least kept at low levels. If this is not done injury to the crop due to the action of the herbicide may exceed any benefits derived from reduced competition due to control of the weeds. Obviously the use of an herbicide on field crops will not be considered practical by farmers if the crop is seriously injured or if little or no increase in yield is derived from its use.

There are at least several hundred corn inbreds and even more hybrids in use in the United States. It would be confusing to you if I attempted to evaluate the sensitivity of these inbreds and hybrids to herbicides. Workers in a number of experiment stations have started to evaluate the inbreds and hybrids most useful in their areas and you can refer to their work for this information. Instead I will attempt to describe the ways in which corn inbreds and hybrids vary in their responses to herbicides. Attention will also be given to methods of determining varietal differences more exactly and to some of the practical considerations.

It has been known for many years that varieties of plants varied in their response to herbicides. The early work with dinitros showed that barley varieties varied in their tolerance of this herbicide. As early as 1945 it was noted that individual plants of chickweed and marigold varied in their tolerance to 2,4-D. By 1946 there was considerable evidence that varieties of corn varied in their response to 2,4-D. Since that date varietal differences to herbicides have been shown to exist in flax, oats, wheat, barley, bent grasses, strawberries, potatoes and a number of other crops.

Corn is generally more sensitive to the action of 2,4-D than any of the grain crops. The variation between inbreds or hybrids has also been shown to be greater than the variation between varieties of any of the grains. For this reason the use of 2,4-D for weed control in corn is more hazardous than its use in grain crops. An especially sensitive line of corn may be treated inadvertently or at an especially sensitive stage and serious injury will result. Incidently this variation between lines is of considerable value to research workers for it allows them to study in greater detail the factors that influence the sensitivity of plants to 2,4-D.

There is no question but that the sensitivity of corn to 2,4-D has been studied more extensively than its sensitivity to any other herbicide. There is some evidence that corn inbreds vary in their sensitivity to CMU. Other studies have shown that varietal differences occur following treatment with 2,4,5-T, dinitros IPC and naphthalene acetic acid. It may be that the differences are not as marked in all cases as with 2,4-D but we can assume that they need to be considered whenever a new herbicide is likely to be used widely.

The corn plant shows a number of responses to 2,4-D depending largely on the time of application. Root growth may be inhibited or shoot growth stunted. These responses determine in part the tolerance of corn to pre-emergence treatments. We know that some inbreds will make good growth following an application of 8 pounds of 2,4-D per acre while others will show injury following an application of only 2 pounds. At later stages of application rolling of the leaves may prevent optimum growth. Brace roots may proliferate instead of developing normally. Stalks may show varying degrees of curvature following treatment. In some cases the stalks become brittle and break off. Again some lines show marked responses following application of as little as 0.25 pounds of 2,4-D per acre while others show little injury following treatment with 1 pound.

Application of 2,4-D at certain stages later in the season is known to cause tassel abortion or sterility. A closely associated effect is ear abortion and barren ears. In some instances, 2,4-D applications have been reported to effect viability of seed produced on treated plants and even to effect the vigor of seedlings produced from such seed.

The responses of the corn plant to applications of 2,4-D are not of equal practical importance. Inhibition of root growth and stunting of shoot growth may be only temporary allowing the plant to recover. Leaf rolling may delay maturity of the plant or prevent tasselling and silking. Stalk bending is spectacular but in itself is usually not serious for the plants recover and make nearly normal growth. Stalk brittleness is probably the most dangerous response. The brittle stalks often break off during wind storms, during cultivation later on in the season, or in extreme cases as a result of the plant growth itself. Stalk brittleness is especially serious when it is combined with stalk bending for the stresses in the stalk are more severe when a bent and brittle stalk is twisted and a high percentage may break. Broken stalks reduce the stand on the field and may easily result in significant reductions in yield.

Applications made somewhat later in the development of the corn plant cause tassel sterility and barren ears. Such responses appear most frequently from over-all applications made to large plants just prior to tasseling and silking. Ordinarily not many fields are treated at this stage but the injury when it occurs reduces yields substantially. The evidence to date indicates that the period of maximum sensitivity is very short. This increases the probability of a field escaping the injury but when it occurs increases the possibility of its severity.

One of the outstanding facts that has come to view as a result of the work to date is that a line of corn sensitive to 2,4-D at one stage of development is not necessarily equally sensitive at other stages. In the injuries described various tissues of the plant are responding to 2,4-D. They involve root tip meristems, intercalary meristems, adventitious root initials, leaf primordia and floral primordia. It is not surprising that sensitivity at one stage gives little indication of the sensitivity at other stages. The different tissues of any one plant are known to vary tremendously in their responses to an application of an herbicide. Apparently this variation is not uniform but also varies from inbred to inbred.

The determination of varietal differences is not as easy as it might appear. One of the problems is to rule out differences due to variations in growth stage of the inbreds at time of treatment. We place inbreds and hybrids into groups of approximately equal maturities. For commercial use it makes little or no difference if they vary a few days in maturity. However, their sensitivity to an herbicide may be markedly affected by a difference in maturity of only one day. Sensitive periods are sometimes of very short duration. This problem of variable maturity

can be solved in part by making repeated applications to the varieties in the study at intervals of no more than 1 or 2 days. In this way it is possible to make some applications at equivalent stages of maturity. The estimates of sensitivity are likely to be more accurate but we cannot assume that environmental conditions will be the same on the different dates.

Ordinarily environmental conditions vary considerable from day to day. Temperatures vary, amounts of sunlight received vary, humidity varies, rainfall and soil moisture vary. Any or all of these factors may possibly effect the response of a plant to an herbicide for they are known to influence the speed of herbicide absorption and translocation as well as cellular responses. It becomes apparent then that it is difficult to test several inbreds or hybrids under identical or even similar stage of development and environment. Probably the most exact work could be done in irrigated regions where soil moisture can be maintained at uniform levels and where other factors of the environment are less subject to fluctuation. Use of ordinary green house facilities appears to be of only limited value for development of the corn plant is seldom normal under these conditions.

To date there has been no conclusive evidence that any type of corn is particularly sensitive to the action of 2,4-D. A range of response is known to exist in dent corn, in sweet corn and even in pop corn. The most uniform responses have occurred when inbreds are treated. Inbreds have been selected for uniformity of growth so it is not surprising that they may show a uniform response following treatment with 2,4-D. This uniformity may make injury severe if it involves a type of injury that occurs within a short period of time, as for example barren stalks.

Single and double hybrids frequently show more severe injury than inbreds but all plants are not as likely to be affected uniformly. The increased vigor of the plants themselves is probably responsible for the more pronounced effect. Open pollenated varieties of corn can be expected to show the least uniformity of injury and the least total injury as well.

We do not yet have complete evidence on the manner in which resistance to 2,4-D is inherited. The data support the belief, however, that tolerance or susceptibility of lines of corn to this herbicide are governed by genetic factors. This being so it should be possible to develop hybrids on which 2,4-D can be used much more freely than at present.

Today we have available three approaches to the problem of varietal differences in sensitivity to herbicides. We may recommend the application of minimum rates of the less toxic preparations of the herbicide at the less sensitive stage of growth and by methods that are known to be less hazardous. This is the approach we have followed in past years. No distinctions are made between inbreds or hybrids for the recommendation is designed to avoid injury to the more sensitive types. It is hoped that at least reasonable weed control will be obtained when these recommendations are followed and that crop injury will be rare. Under unusual conditions or with especially sensitive hybrids it is likely that some injury will result.

A second approach to the problem is to evaluate our inbreds and hybrids for sensitivity to herbicides and to make our recommendations on an individual basis. It would not be impossible to evaluate the hybrids now in use for at least several of the types of sensitivity now known to exist in corn. Publicizing this material and enabling farmers to use it in their farm operations seems a more difficult matter. Hybrids in use are constantly changing and at any one time an individual may be able to make a choice of a dozen or more for use on a particular farm. I am not hopeful that there will be opportunity or inclinations to select a hybrid with its tolerance to herbicides in mind.

The third approach utilizes our knowledge of inbred tolerance to herbicides to develop hybrids that are unlikely to be injured by any reasonable application. If all or most of the hybrids released in the future were developed with this thought in mind the farmer need not be greatly concerned about varietal differences. He could apply herbicides to any well recognized hybrid with the assurance that injury would not occur. If such hybrids were made generally available it is likely that our recommendation for use of herbicides on corn could be made more liberal. At present we are limited to applications that presumably can be used with safety on all but our most sensitive lines. If application rates could be raised slightly and applications made over a greater period of time it seems certain that more satisfactory weed control would result. Our hope for the future appears brightest if this approach can be utilized.

FIELD OBSERVATIONS OF WEED CONTROL IN CORN

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Urbana, Illinois

In spite of the tremendous advancements that have been made in chemical weed control in corn, weeds still remain as the Number 1 pest to the Illinois corn crop.

2,4-D has been readily accepted by Illinois farmers and presently is being used on about 5 percent of our corn acreage annually. We need a good pre-emergence herbicide for corn, the results with out present chemicals have been so variable, this type of treatment has not been readily accepted by our farmers.

One obstacle to the greater use of 2,4-D as a post-emergence treatment on corn has been scattered cases of injury. The most important type of corn injury in Illinois has been stalk brittleness. Seldom a year goes by in Illinois but what a farmer suffers serious loss of stand due to stalk breakage. In the past we feel that the majority of these injury cases can be explained by miscalculation of either the sprayer or the spray material. Unfortunately this does not explain all of our injury cases and under some conditions even with the most careful application corn becomes brittle. Brittleness seems to be associated with environmental conditions. When conditions are favorable for rapid growth of corn we are very apt to get stalk brittleness. It appears that the best thing we can do to avoid brittleness is to stay out of the corn field with our sprayers when corn is growing rapidly.

The immediate effect of using 2,4-D in our corn fields has been to reduce our weed problem,

but it may be having a more serious effect on the types of weeds present. We have noticed a gradual change from broadleaf weeds to grasses in our cornfield. This has been true because by killing the broadleaf weeds with 2,4-D, the grass weeds increase and multiply. If this trend continues we must either develop pre-emergence sprays more fully or find a post-emergence spray for corn that will kill annual grasses without hurting corn.

FIELD OBSERVATIONS OF WEED CONTROL IN CORN

J. Ross Fleetwood
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Columbia, Missouri

In order to give you the proper perspective to use in judging a report on field observations of weed control in corn in Missouri, I would like to say that some 18,000 farmers sprayed some 410,000 acres of corn with 2,4-D in 1953. This represents roughly 10 per cent of the farmers growing corn and 10 per cent of the total acreage of corn grown in the state.

Bottom land soils make up 20 per cent of the total land area in the state and I suspect that nearly one-half of our total corn acreage is on bottom land. Much more than 50 per cent of the corn sprayed is on bottom land where annual weeds are a perennial problem.

The acreage sprayed is an increase of some 20,000 acres over last year. In view of the statewide shortage of moisture--a bit of English understatement--weeds were not nearly as serious as usual and I for one was surprised that we actually showed an increase this year.

Method of application. Our county agents report 9,320 power sprayers owned by farmers. This represents slightly more than the statisticians one-half sprayer per farmer who sprayed corn in 1953. Thus nearly 50 per cent borrowed or rented a sprayer or hired a custom operator. I have no data to back up this observation but I believe that custom spraying is on the increase. We know positively that airplane spraying is growing. Our observations do not indicate a significant difference in results based upon the method of application utilized.

Results secured. Excellent control of weeds has been secured in general. I often feel, better than any of us had any right to assume, could be secured. Even where the weeds are not killed completely, seed set has been reduced and growth frequently set back to such a degree that damage to the corn was insignificant.

The killing of the weeds has, however, in some instances, permitted grasses such as Setaria faberi to develop more vigorously.

Good results apparently are not dependent upon the type of material used, the method of application, or the time of application.

Injurious effects. Injurious effects from post-emergence sprays serious enough to significantly affect yields, have been observed in relatively few instances. In most of the cases observed the damage has occurred because of breakage from an unfortunately timed wind storm. Over-spraying has, in some instances, caused twisting which interfered with harvesting even though no significant reduction in actual yield could be detected.

Pre-emergence spraying has adversely affected stands in too many instances and weeds have not been controlled in others. However, the practice is being used on some of our heavy poorly drained soils. Those who have used lay-by sprays at or near pre-emergence rates are very much pleased with results. They feel that on much of our land where grasses are a serious problem, this practice has particular merit.

Summary. Observations may be briefly summarized as follows:

1. Post-emergence sprays have been generally successful, with no significant difference in results from the material used, or the method of application utilized.
2. The time of application has not made a significant difference in results, except at the time of fertilization and the increased hazard of breakage where the corn is larger.
3. Damage to corn severe enough to cause a significant decrease in yield is very rare.
4. Both the higher concentration, pre-emergence and the post-cultivation sprays are gaining in popularity.
5. Our corn growers have found 2,4-D useful in controlling weeds in corn--10 per cent of the total acreage is now sprayed. However, the 90 per cent not now sprayed indicates that they have found chemicals a good tool in controlling weeds but not necessarily the only or even the best means of doing so.

PRE-EMERGENCE HERBICIDES ON CORN

C. J. Willard
The Ohio State University
Columbus, Ohio

Pre-emergence herbicides on corn are much like the little girl with the curl. When they are good they are very, very good, and when they are bad they are awful. The uncertainties connected with 2,4-D pre-emergence and the much greater cost of present pre-emergence treatments have combined to make them much less used than post-emergence, and properly so.

However, no one who has seen the beautiful results achieved by good pre-emergence treatments is going to be happy not to at least make a vigorous effort to bring these results into regular, predictable, use. This is not as simple as it seemed six years ago. The interrelations between the herbicide, the particular compound used, the rate of application, the stage of growth, the conditions of growth, temperature, and a multitide of other factors, are quite sufficiently confusing for post-emergence applications. For pre-emergence, we have all of these factors to consider, and in addition, all of their interactions with the soil; its texture, clay content, organic matter content, pH, and so on. Some herbicides react with

the soil, some do not. Some formulations react with the soil, some do not. So only painstaking research can determine how best to use any given pre-emergence herbicide.

Furthermore, for most of our cornfields, we are at the mercy of the weather. After planting the corn and applying herbicides we may have no rain, a little rain, or excessive rain; we may have hot weather, medium weather or cold weather; and these make a vital difference in our results.

If we continue for a few more years to spray corn with 2,4-D post-emergence, the population of the weeds susceptible to 2,4-D will be greatly reduced in the soil, and at the same time the population of grasses and of certain broad-leaved weeds which are tolerant to post-emergence 2,4-D will be greatly increased. Then (and the time is not too far off) it will be necessary for us to find some other method of treating corn besides post-emergence 2,4-D. As this condition develops, there will be increasing place and demand for pre-emergence 2,4-D applications and for other and more effective pre-emergence herbicides.

The essential practical facts concerning pre-emergence 2,4-D applications have been part of Conference recommendations for some time. They include a rate of one to two pounds per acre, treating, if possible, a few days after planting the corn, using ester formulations in preference to amine formulations, avoiding use of pre-emergence 2,4-D on sandy open soils, and using higher rates on soils with high organic matter than low organic matter.

Unfortunately, it is so far true that there are chances for disappointment and some hazards connected with this program. However, on loams, silt loams and clays the chance for injury to the corn is small. If the soil is dry when the application is made and no rain falls for two weeks, many weeds will establish, resulting in loss because of the high cost.

Despite these chances, it seems probable that we will see considerably more pre-emergence applications in the future than in the past. The only way that we have any opportunity to control grass weeds with 2,4-D is pre-emergence. Furthermore, pre-emergence applications control all weeds at the time when we most want to control them - in time to do away with the tedious, expensive, and time-consuming first cultivation. With a good pre-emergence application, one cultivation usually, or, at the most, two, will be sufficient, and these can be made late enough so that they can be done very rapidly and economically.

Because of the importance of the soil factor in pre-emergence application we have been making a laboratory study of the interrelations of 2,4-D formulations with soils and soil materials for several years. Except for the well-known greater fixation of esters over amine salts, which seems to be definitely related to the oil in which the esters are applied, we have so far little to offer of immediate value to the corn growers.

The search for safer more effective pre-emergence herbicides is encouraging. A well-established herbicide, the alkanol amine salt formulation of DNBP, has been widely and successfully tried. Actually, it is most economically successful as a very early post-emergence spray, at the rate of about 3 pounds per acre. The young corn, from the coleoptile to the two-leaf stage, is burned more or less, but recovers without loss of yield, while the seedling weeds, just through the soil, are killed. Five to seven pounds per acre can be used before the corn emerges, but the dinitro evaporates fast enough so that it is best applied to contact the weeds.

The most sensational new pre-emergence herbicide is CMU, 3(parachlorophenyl)-1,1-dimethyl urea. Its extreme toxicity and low solubility combine to make it more effective on surface-sprouting weeds than on the deeper-planted corn. Corn also has considerable tolerance for CMU, when compared, for example, with soybeans. It has been successfully used experimentally clear across the corn belt at 1 to 2 pounds per acre - ½ pound has not been effective on silt loam and clay soils. (Soil type greatly modifies results.) The greatest problem with CMU is the possibility of building up toxic quantities of this very durable material in the soil, but if only the corn crop were concerned, we have suggestive evidence that this could be met.

CIPC at rates high enough to control weeds is definitely hazardous to corn, and can hardly be recommended.

It is a safe guess that the organic chemist will later give us even more effective pre-emergence herbicides. But these are an excellent start.

FIELD OBSERVATIONS OF WEED CONTROL IN CORN

E. P. Sylwester
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Ames, Iowa

In 1953, Iowa's corn crop is estimated at 589,142,000 bushels from 11,012,000 acres with an average yield of 53.5 bushels per acre. This is 16 percent less than the 1952 crop of 697,792,000 bushels from 10,799,000 acres at an average yield of 64 bushels per acre, but it is 11 percent more than the 1942 - 1951 average.

Corn in Iowa in 1953 was planted ahead of average under almost ideal conditions, had very favorable weather and 85 percent of the crop was laid by as of July 6, which was well ahead of the average time when corn is normally laid by. Some local hail storms, flooding, cutworm and wire worm damage was experienced but in general, prospects were good. We received enough early rain that the crop grew extremely fast. Estimates are that about 500,000 acres of corn were sprayed with tractor-mounted or trailor equipment prior to the time it was laid by. This would include some pre-emergent spraying and increasing amount of spraying just as the corn emerged or was one or two inches high and the remainder at lay-by time. Due to the extremely fast growth of the corn, hurried cultivations were in evidence.

We had estimates of the third largest crop on record as of July 1, being exceeded only by the 1948 and 1952 crops of 677,000,000 and 697,000,000 bushels respectively. Excessive high temperatures at pollination time resulted in unfilled eartips throughout the state. The main cause of corn yield reduction, however, was an extended drouth from August 1 until after corn

harvest, was for the most part, completed. This corn harvest, over the state, was also well ahead of schedule. Only in northern and north central Iowa were conditions for corn growth and development anywhere near normal. Much drouth injured corn ripened prematurely and was harvested for silage especially in southern Iowa. Much corn was light and chaffy, but what did ripen matured ahead of frost and was, for the most part, of good quality.

With the hurried cultivations necessary and with the rainfall conditions about normal until August 1, many fields became quite heavily infested with grassy weeds, especially green foxtail, yellow foxtail, bristly foxtail, some giant foxtail, sandburs, and barnyard grass. Also, Mexican dropseed grass became a pest in many clean cultivated cornfields this immediate past season. Several fields were observed where this plant had secured a thorough foothold and was causing considerable damage. Some corn was sprayed with high clearance machines after it was laid by for the control of annual broad leaved weeds with relatively good success. Later sprayings after corn pollination was completed gave, for the most part, poorer results because (1) hot, dry weather had hardened the weeds and (2) dosages were not increased because of the weeds hardening off. Only scattered instances of true pre-emergent spraying were reported. Increasing instances of small corn spraying were reported this year over last year.

Many fields which were laid by early because of the fast growing corn became somewhat weedy later on. This is especially true as it concerns the foxtails and barnyard grass. Corn was laid by ahead of schedule. Rains occurred after this laying-by process and many grassy weeds germinated, and the ones which survived cultivation secured a foothold and maintained themselves throughout the remainder of the season. Many farmers even after spraying broad-leaved weeds suffered heavily from grassy weed infestations. Some of the over-all decrease in yield experienced by Iowa farmers this year can undoubtedly be contributed to heavy weed growth which drained soil moisture and nutrients.

In summary, the following observations appear important: (1) a small amount of pre-emergent spraying which was done gave good results using dosages of 1 to 2 pounds per acre. (2) Spraying of real small corn, just when it is coming up and when it can be rowed, that is, when it is 1 to 2 inches high, is gaining in popularity, especially in those fields known to be heavily infested with morning glories, cockleburs and smartweeds. Dosages of 1/2 pound of 2,4-D per acre of the amine type or 1/4 pound of the ester type seemed sufficient at this stage. (3) Sprays at lay-by time again this year as in other years caused scattered reports of damage, due to over-dosing, brittleness, heavy winds, onion leaf, etc. Farmers are becoming more reluctant to spray right at lay-by time although many of them still believe that this is the proper time to spray using the drop extensions, being careful not to overdose and spraying the corn when it is actually suffering from lack of moisture and not growing too rapidly. (4) Sprays immediately prior to pollination, using high clearance equipment and drop extensions gave good results but spraying at this time due to press of other farm work is not very popular. (5) Sprays after pollination was completed gave good results when higher amounts of 2,4-D were used, namely 1 pound per acre of the amine type of 2,4-D or 1/2 pound per acre of the ester type but mediocre to poor results were obtained when 1/2 pound rates of amine or 1/4 pound rates of ester were used. The weeds had undoubtedly hardened off because of the hot dry weather. (6) Foxtails of all kinds, sandburs, barnyard grass and Mexican dropseed grass increased in severity. A good grassy weed retardant at corn lay-by time should prove highly effective because grassy weeds seem to be more prevalent in Iowa this past season than they have been for some years past. (7) Best times when farmers prefer to spray corn appeared to be pre-emergent (2) when corn was just coming up or 1 to 2 inches high, (3) at lay-by time, if weeds are extremely heavy and bothersome and if thorough cultivation hasn't controlled them adequately (4) after about 25 percent of the silks have started to turn brown, provided the dosage of 2,4-D has been increased.

FIELD OBSERVATIONS IN INDIANA

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Lafayette, Indiana

Spraying with 2,4-D (2,4-Dichlorophenoxyacetic acid) to control weeds in corn is an established farm practice in Indiana. It has been most practical and economical in fields where susceptible broad leafed weeds are persistant. It is also considered an emergency measure when weeds threaten to ruin the corn crop during and following periods of wet weather when timely cultivations, to control weeds, are not possible. In many such cases, spraying has saved the crop. Spraying is not recommended to replace cultivation but to be used in conjunction therewith in fields where ordinary cultivation will not do an adequate job of weed control.

We have approximately 4,600,000 acres of corn in the state. It is estimated that the average annual acreage sprayed is about 230,000 or about 5 per cent of the total. This 5 per cent is estimated to be nearly all corn grown on bottom lands and fields infested with weeds that are difficult to control. Where wild cucumber is a problem, a mixture of equal parts of 2,4-D and 2,4,5-T is used with good results.

Practically all of the 2,4-D used in corn is applied as a post-emergence application either on small corn or just before corn is laid-by. Pre-emergence applications are not popular. This is true mainly because results are somewhat unpredictable. Results have not been consistent. A few popcorn growers are using it with success as popcorn is slow in starting, therefore, keeping weeds down during the early part of the season is essential.

Very few cases of injury to corn have been noticed or reported during the past few years. A few farmers have had some lodging from spraying with 2,4-D when corn is 24-30 inches in height. A part of this difficulty is the result of improper adjustment of "drops". When drops are used and where weeds are found only in the row there is a tendency to direct the spray onto the row only. When the rate used for over-all spraying is applied in this manner it results in too heavy an application to the corn. There are also a few cases where too much 2,4-D is used. The general recommendation is to use from 1/4 to 1/3 pound of 2,4-D in 10 gallons per acre.

Since grassy weeds are becoming more and more of a problem in corn, farmers are interested in herbicides that will hold them in check. For this purpose as well as for the control of broad leafed

weeds, dinitro (DNBP) has shown promise when applied as a pre-emergence application. During the past summer we made an attempt to determine the tolerance of sweet corn, popcorn and dent corn to DNBP. This particular experiment was conducted on a Crosby silt loam. Rates of 12, 14, 16 and 18 pounds of DNBP (actual) were applied 24 hours after planting. The sweet corn used was KVF 51-180, the popcorn was Purdue 202 and the dent corns were Ind. 620 and Ind. 813. Sweet corn and popcorn appeared to be more susceptible to injury than the dent corn hybrids. Sweet corn stands were reduced by all rates used. The 18 pound rate reduced the stand of popcorn while the dent corns stands were not reduced. All rates used caused temporary stunting of all hybrids tested. All rates produce excellent weed control during the early part of the season. Incidentally, giant foxtail (Setaria faberi) was retarded by the 12 pound rate and controlled, except for late germinations, by the heavier rates.

As the cost of over-all treatments at these rates is high band treatments, applied over the row, appear to be more practical. If 40 inch rows are used, an application of a 10 inch band over the row will reduce the cost to one-fourth. The weeds between the rows can be destroyed by timely cultivations.

Other tests using DNBP as a post-emergence treatment on corn have shown some promise. Rates of 1.5, 3.0, and 6.0 pounds per acre were applied at two stages of growth of corn, 2-3 leaf stage and 5-6 leaf stage. The 1.5 pound rate when applied in the early stage of growth reduced weed stands some 70 per cent and only caused slight retarding of the corn growth. The later applications were not effective as weeds were too well established at the time the treatment was applied. The 3 pound rate when applied when the corn was in the 2-3 leaf stage reduced the stand from 10-20 per cent, while the 6 pound rate reduced the stand of corn approximately 50 per cent. From this work it appears that rate and timing of the application are critical. It is worthy of further investigation.

We need a herbicide that will selectively control Johnson grass and giant foxtail in corn. The preference would be one that can be applied as a post-emergence treatment. This is asking a lot, I know, but it is badly needed.

CONTROL OF WEEDS IN PASTURES

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Weeds are a problem in pastures in all states of the North Central Region. While weed problems in pastures vary to some extent with location in the region, there is a great deal of similarity in the species of greatest importance in these various locations. Ironweed and ragweeds would certainly be high on the list of pasture weed problems in most of the states.

Fertilization accompanied by plowing and reseeding to adapted forage species will usually result in good weed control with most pasture weed species in areas where such practices can be adopted. However, there are many areas in which such practices are not followed. In these situations mowing has long been a universal recommendation for pasture weed control. 2,4-D is now being used to a limited extent for such weed control.

Rather than my making a survey type of report to this group about pasture weed control, I have decided to talk in some detail about a study being conducted at Lincoln, Nebraska. This study is a comparison of mowing, 2,4-D and plowing and reseeding to grasses for weed control. The material presented will have application in a general way to pasture weed problems in much of the North Central Region.

Materials and methods. This study was established in a weedy pasture located 10 miles south of Lincoln. Predominant weeds were Ironweed Vernoia baldwinii Torr., False Boneset Kuhnia glutinosa Ell., Hoary Verbain Verbena stricta Vent., Many-Flowered Aster Aster multiflorus Ait., Annual Ragweed Ambrosia elatior L., Hairy Chess Bromus commutatus Schrad., and Triple-awn Aristida oligantha Michx. The main desirable grasses were Bluegrass Poa pratensis L., with scattered stands of Sideoats Gramma Bouteloua curtipendula (Michx) Torr., Sand-Dropseed Sporobolus cryptandrus (Torr.) A. Gray, and Big Bluestem Andropogon gerardi Vitman. Weed control treatments as indicated in figure 1 were (1) Check, (2) Mowed in June, (3) Mowed early July, (4) 2,4-D ester (1 pound per acre) in June, (5) 2,4-D in July, (6) Intermediate wheat grass Agropyron intermedium (Host.) Beauv., (7) Bromegrass Bromus inermis Leyss, and (8) Warm Season Grass Mixture (big bluestem, switchgrass Panicum virgatum L., sand-lovegrass Eragrostis trichodes (Mitt) Wood, and blue grama Bouteloua gracilis H.B.K. Lag. ex Steud). The grasses were planted in the spring of 1950 on areas plowed in the fall of 1949. The seeded grass plots were sprayed with 2,4-D ester in the 1950, '51 and '52 seasons with 1/4, 1/2 and 1 pound per acre, respectively (Mowing was substituted for the 1950 spray treatment in the Warm Season Grass Mixture). Three levels of grazing management were superimposed upon the above weed control treatments. They were "Grazed as Usual" for the Pasture, "Deferred and Rotationally Grazed" and "Permanently Protected". The experiment was replicated four times. Supplementary studies, comparing eight dates of mowing and spraying ironweed, as indicated in figure 2, was initiated in the springs of 1950 and '51.

Data and discussion. In figure 1 is shown the overall effect of weed control treatments on the important annual and perennial broad-leaved weeds. These data were obtained in June of 1953, prior to the current year's weed control treatment; therefore, they represent the residual effects of previous years' treatments. The perennial weeds were affected by the two dates of mowing approximately equally and gave about 35% reduction in stand compared to the check treatment. The two corresponding dates of 2,4-D treatment gave somewhat better control than did the mowing with approximately 70% control of all important perennial pasture weeds. Plowing and reseeding to grasses supplemented with annual 2,4-D treatments gave about 90% control of perennial weeds.

Effects of treatments upon annual weeds were somewhat different from that with perennial weeds. The June mowing date did not reduce the total number of annual weeds, while the plots mowed in early July gave satisfactory control and had about the same number of annual weeds as the plots sprayed in early June (56% reduction). Those treated with 2,4-D in July gave 75% control. Control in the Intermediate

wheat, Brome and Warm Season Grass Mixture plots were 62, 79 and 95% control, respectively.

Relatively poor control of Ironweed by mowing was a little unexpected in light of the work reported earlier by Aldous[1]. The reasons for differential results between those reported herein and those of Aldous are not known. As indicated in figure 2, mowing was less effective for control of ironweed than 2,4-D. The best dates for mowing ironweed range between June 5th to July 3rd, with somewhat poorer results on dates of mowing July 17th and thereafter. The best dates of spraying with 2,4-D coincide quite closely with the best dates of mowing, with the 2,4-D ester showing a slight advantage over the amine salt later in the season.

The individual reaction of broad-leaved perennial weed species to weed control treatments will be mentioned briefly without showing detailed data. The most effective weed control treatments of Ironweed was plowing and reseeding to grasses accompanied by 2,4-D treatment. This is followed by treatments with 2,4-D in June and 2,4-D in July. Mowing in June was only moderately successful.

The only treatments for false boneset which were satisfactory were those plots plowed and reseeded to the various grasses. 2,4-D in July was moderately satisfactory (60% control) and gave better control than 2,4-D in June.

All treatments except the mowing in June and check gave satisfactory results with hoary vervain. The same was true with many-flowered aster.

With yarrow mowing was unsuccessful; treatments with 2,4-D gave 53 and 67% control respectively in July and June treatments.

Annual ragweed is by far the most important of the annual broad-leaved weeds in pastures. Mowing in June was ineffective on this species, while plots mowed in July gave about 60% control; 2,4-D applied in June, approximately 60% control; while 2,4-D applied in July gave 75% control. Intermediate Wheat Grass and Brome gave 63 and 80% control, respectively, while the Warm Season Grass Mixture gave 97% control. Each of the seeded grass plots were also treated with 2,4-D.

The other species were relatively unimportant in this pasture and will not be discussed.

In figure 3 is shown the percentage basal density of grass in June 1953, as affected by weed control treatments. In the first 5 treatments, in which the soil was undisturbed, basal density of desirable grass was to some extent inversely related to the control of weeds. Basal density of the weedy grasses was not affected by the treatments, although there was some reduction in most of the treated plots as compared to the check. Intermediate Wheat Grass showed a small increase in weedy grasses. This was primarily due to the invasion of weedy grasses on the closely grazed "Grazed as Usual" plots in which stands of Intermediate Wheat Grass had been thinned.

The foregoing discussion has been limited to stands of the various species; however, the relative production of plant material by the various types of vegetation is also of importance. In figure 4 is shown the effect of weed control treatments upon the total production of dry matter per acre. These data are an average of production in the 1951, '52 and '53 seasons. The low total production from the mowed plots is partially due to the method of sampling which failed to recover much of the mowed plant material. The total production of dry matter on the last 5 plots shown, upon which good weed control was obtained, is almost equal to that of the check. A generalization might be made that the total production of dry matter was not greatly different for the areas regardless of whether weeds were present in the pasture plots or not. This varies, however, somewhat with the seasons. In 1951, a very wet season, those plots having good weed control produced somewhat greater amounts of dry matter than did the weedy check, indicating that under very wet conditions the grasses had a slight advantage. In 1952, a year of more nearly average rainfall, the production of plots having weed control was slightly less than that of the weedy check. While in 1953, a severe drought year, the weedy check definitely produced a higher yield of plant material than those plots having weed control. Under very dry conditions the deep-rooted perennial weeds appeared to have advantage. Recognizing these seasonal variations, it is interesting, nevertheless, that these last five treatments in the last three years have averaged 92% of the check in total plant material production.

While the total production does not differ greatly with weed control treatments (excepting mowing), the vegetation making up that total production was greatly different. A closer study of figure 4 will show that broad-leaved weeds made up greater than 50% of the total production from the check plots, and less than a third of this total production was made up of desirable grasses; while less than 20% of the total production of the last five treatments was made up of broad-leaved weeds. With the exception of the mowed plots, a decrease in broad-leaved weeds was compensated for by a large increase in desirable forage species. There was also some compensating increase in production of weedy grasses. As indicated in figure 3, a part of this increased production of desirable forage species is the result of increased stand. Also, part of it is due to increased vigor of the desirable plants.

While the total production of plant material, and its components, is of interest, the amount eaten by cattle of these various vegetational components is also of importance. In figure 5 are shown the effects of weed control treatments upon the average amount eaten in pounds of dry matter per acre. The broad-leaved weeds and weedy grasses furnished considerable forage in these pastures. In the check, over one-half of the forage eaten was made up of weeds (broad-leaved and weedy grasses). The same is true of the plots receiving the mowing treatments. A little less than one-half of that eaten was made up of weeds in the 2,4-D treated plots and intermediate wheat grass, while in the brome and warm season grass mixture plots only a little more than one-third of the total eaten was made up of weeds. Detailed information concerning which species furnished the grazing is not available. Cattle quite readily grazed dandelion and ate considerable ragweed, although it was not relished. Species usually avoided in grazing included ironweed, false boneset, yarrow Achillea millefolium L., and milkweed Asclepias syriaca L. (although it was preferentially grazed in 1953). The weedy grasses eaten were primarily the weedy-bromes in the younger stages and triple-awn, while it was still quite small.

(1) Aldous, A. E., Management of Kansas Permanent Pastures. Kans. Agri. Expt. Bul. 272. 1935.

Foxtails and barnyard grass also furnished considerable grazing on the reseeded pasture plots.

Increasingly higher amounts of desirable forage species were eaten on the plots with better weed control. The mowed plots had increased consumption of desirable vegetation of 146% and 120% of the check, while the 2,4-D plots had 162% and 172%. On the reseeded plots the desirable species forage eaten was 257%, 379% and 408% that of the check, respectively, in the intermediate wheat, brome and warm season grass mixture.

The amount of aftermath left of the desirable grass species in the 2,4-D treated plots was considerably greater than that for the check. The amount remaining on the reseeded pastures was slightly less than the check, and on the mowed plots about three-fourths as much aftermath of desirable forage species was left as was left on the check.

Summary. Of the weed control methods used, the plowing and reseeding to adapted grasses supplemented with 2,4-D were the best, giving in excess of 90% control of perennial weeds. These treatments were followed by the 2,4-D treatments which gave in excess of 65% control of all perennial weeds. Mowing was relatively unsatisfactory for perennial weed control with approximately 35% reduction in stand. With the annual weeds, primarily Annual Ragweed, all methods gave better than 55% control, except the mowed in June treatment and the check. The 2,4-D applied in July was slightly superior to the mowed treatment in July for control of annual broad-leaved weeds. Mowing to date has been relatively ineffective in controlling ironweed. The best dates for spraying ironweed with 2,4-D are between June 5th and July 17th. The ester was slightly more effective than the amine salt later in the summer. The best times of spraying and mowing appear to coincide for ironweed.

Reduced stands of broad-leaved weeds resulted in increased basal density of the desirable grasses.

The three year average total production of vegetation has been similar on all treatment plots (except mowing) even when the weeds were eliminated. The reduction in production of broad-leaved weeds resulting from weed control was largely replaced by greater production of desirable forage species. The consumption of forage tended to be inversely related to the amount of weed control.

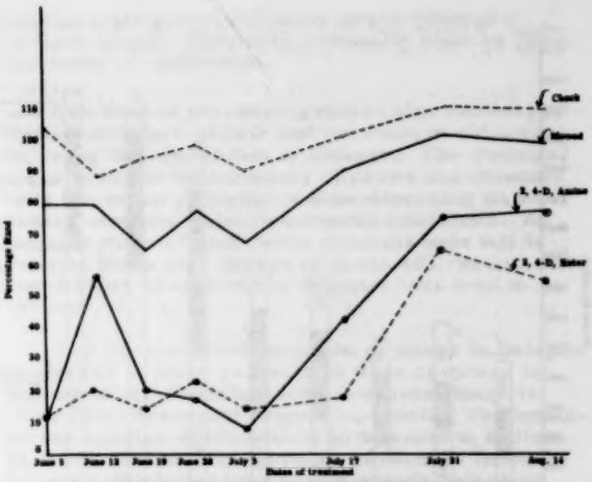

Fig. 2 -- Ironweed stands as affected by dates of mowing or spraying 2, 4-D. Data are an average of two experiments (One treated 1950, 1951 and 1952, and the other 1951 and 1952) at Lincoln, Nebraska. Data taken June, 1952 (prior to 1952 treatments).

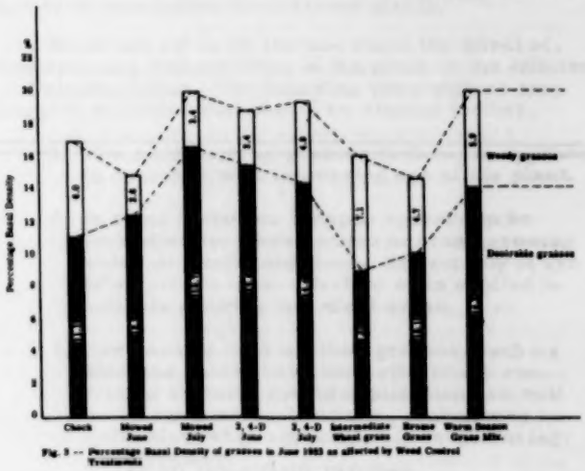

Fig. 3 -- Percentage Basal Density of grasses in June 1952 as affected by Weed Control Treatments

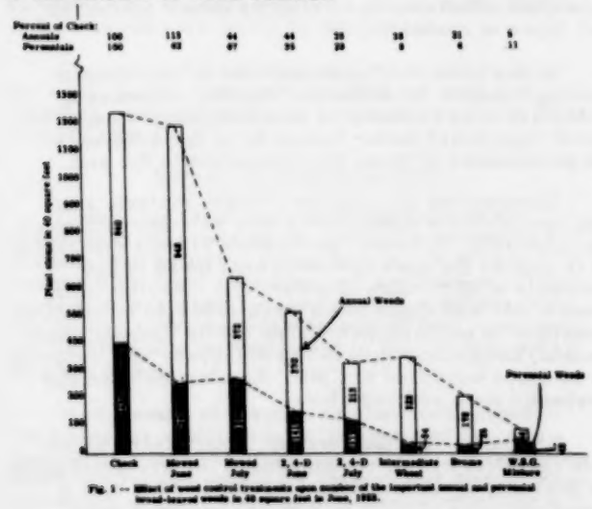

Fig. 1 -- Effect of weed control treatments upon number of the important annual and perennial broad-leaved weeds in 40 square feet in June, 1952.

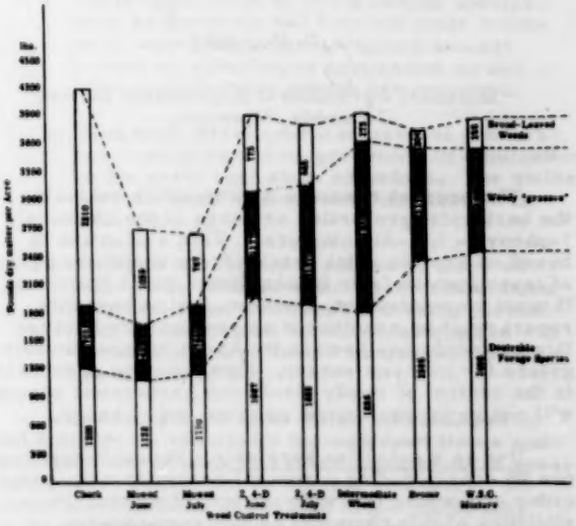

Fig. 4 -- Effect of weed control treatments upon the total production of dry matter per acre. Data are average of 1951 '52 and '53.

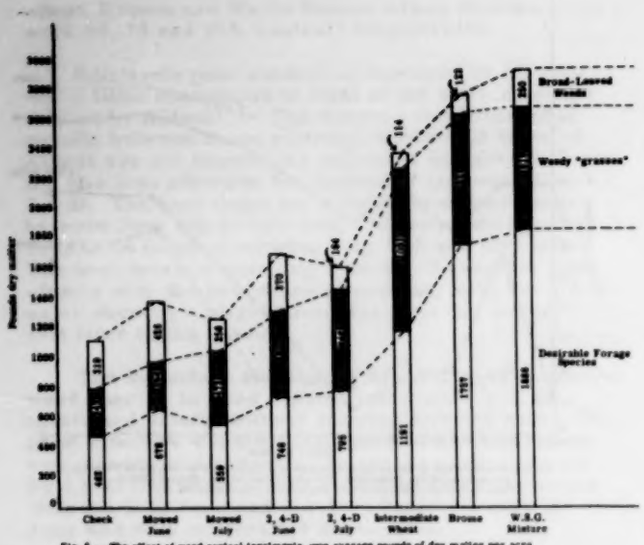

Fig. 5 -- The effect of weed control treatments upon average pounds of dry matter per acre eaten by cattle.

PHENYLDIMETHYLUREA

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The present report is an attempt to evaluate the herbicidal properties or usage of the chemical, 3-phenyl - 1, 1-dimethylurea. This evaluation is based on experimental results from twenty-two groups of investigators from fifteen States and 3 Provinces. It must be pointed out, however, that at best this report must be considered as preliminary because this herbicide has been in the hands of most investigators for only one season. Final results of experiments in the control of woody plants and herbaceous perennials will not be known for two or three years hence.

Use as a selective herbicide. Phenyldimethylurea can be considered as a general herbicide with a high order of toxicity to a wide variety of plants. Possibilities of this chemical as a pre-emergence herbicide have been tested in numerous agronomic crops including corn, wheat, soybeans, cotton, flax, sugar beets, barley, oats, sunflower, safflower, sesame, alfalfa, timothy, and red clover. For cotton, corn, soybeans, and wheat results are contradictory and therefore its use is questionable at this time. Flax, sugar beets, sunflower and safflower appear more sensitive than the above mentioned crops and its use on these crops does not seem advisable.

Phenyldimethylurea has been tested also as a herbicide on several Horticultural Crops including asparagus, carrots, grapes, snapbeans, onions, squash, sweet corn, and Cranberry bogs. Pre-emergence and post-emergence application on onions and peas and selective foliage application on Cranberry bogs appear promising. Results of treatments on other crops were contradictory or indicated that this chemical was too toxic.

Control of perennials. In the control of woody plants such as Mesquite, Post and Blackjack Oak, and Wild Currants (Ribes spp.) insufficient time has elapsed to obtain accurate readings; however, 75 to 100 percent defoliation has resulted in all experiments.

For the control of certain perennial weed pests this chemical gave approximately 90% control of Curled dock, Perennial sow thistle, Ox-eye daisy and King Devil at the rate of 20 pounds per acre. Couchgrass and toadflax require 40 to 80 pounds per acre for 90% control however only approximately 50% control of Chicory is obtained with 80#/A. For sod-killing 20 pounds per acre is effective against Colonial Bent grass. One investigator reported this chemical to be less effective than CMU, Dalapon or TCA for Bermuda grass control.

Field Bindweed, Bladder Champion and sedge appear quite resistant.

Use as a soil sterilant. As a soil sterilant for treating railroad right-of-ways and similar areas it did not appear to have adequate residual properties.

Comparison with CMU. Due to the similarity in chemical and physical properties Phenyldimethylurea was compared with CMU in most experiments. As to effectiveness in controlling annual broad-leaved and narrow-leaved weeds it appears that there is little difference between these two chemicals. Some results indicate that CMU may be more effective in annual grass control while other data indicate that phenyldimethylurea gave slightly better control of all types of annual weeds.

In the control of perennial weeds the mode of killing appears the same and species resistant to CMU are also resistant to phenyldimethylurea. The most significant factor seems to be the difference in persistence of these two chemicals in the soil.

Considering the toxicity of these materials to the various crop plants there may be some difference in selectivity, however, the results are not conclusive. It is only at the very low rates that there is any evidence of difference in selectivity. Barley, oats, wheat, flax and sugar beets were reported to be more sensitive to phenyldimethylurea, while carrots, peas, onions, snapbeans, squash and bluegrass was reported to be more sensitive to CMU. Results for corn and soybeans were contradictory.

Summary. Further testing is necessary before this chemical can be recommended for pre-emergence or post-emergence application. Rates less than $\frac{1}{4}$ pound per acre usually do not give adequate weed

control and rates above 2 pounds cause severe injuries. With most crops 1½ pounds will be maximum rate that can be used. Fifty to eighty percent control of annual weeds is usually obtained at the one pound rate. In the control of woody species it appears that it will be effective on those species that are susceptible to CMU.

Since phenyldimethylurea disappears from the soil more rapidly than many soil sterilants it appears that it may have an important place in the control of deep-rooted perennial weeds where it is essential that the soil be "tied-up;; for a minimum of time.

DALAPON AS A GRASS CONTROLLING HERBICIDE

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Introduction

During the course of investigations of the relationship between chemical structure and plant growth regulator activity it was observed that a,a-dichloropropionic acid (2,2-dichloropropionic acid) induced growth malformations and inhibition in grasses. Subsequent tests showed that the compound had promise as an herbicide and growth controlling agent for a number of annual and perennial grass species.

In May 1953 the name "Dalapon" was assigned to a,a-dichloroproponic acid and at that time its sodium salt was sent to agricultural experiment stations throughout the United States and Canada for a preliminary evaluation. A bulletin issued in connection with this experimental introduction, presented the results of early laboratory and field investigations with Dalapon and suggested further lines of experimentation that appeared promising. A second Dalapon bulletin is now available summarizing the results of 1953 experiments.

Except for use on railroads and other industrial lands no Dalapon (sodium salt) will be sold in 1954, however, experimental quantities will be available for various agricultural applications. It is hoped that the agricultural experiment stations will determine where and how Dalapon may be profitably used so that sound recommendations can be made when it does become available to the farmer.

This paper is intended as a brief summary of the work to date with Dalapon (sodium salt) and includes some suggestions for promising lines of investigation.

Nature of Plant Responses

Controlled laboratory investigations have established that Dalapon is actively absorbed and translocated by living grass foliage. It is also absorbed by roots following soil application. It is most effective when sprayed in such a manner that the foliage is thoroughly wet, and in this connection the addition of a wetting agent to the Dalapon spray is often helpful.

New growth of grasses is often malformed following the application of Dalapon and there is frequently some proliferation of tissue. At suitable rates old foliage gradually yellows and dies. Grass seedlings of many species are often stunted for a considerable period following interception of a Dalapon spray. They may eventually recover from low rates of application.

Established perennial grasses also exhibit malformation of new growth and necrosis of old leaves following the application of Dalapon. The chemical appears to induce dormancy of crown and rhizome buds for varying lengths of time depending on the dosage used and on environmental conditions. At suitable rates of application dormant buds fail to recover and a high degree of grass kill results. At lower rates of application dormant buds tend to recover.

The physiological response of plants to Dalapon is similar in many respects to their response to Sodium TCA. With the latter, however, there is little foliar transport to growing points. The broadleaved species which tend to be tolerant to Sodium TCA are also among the more tolerant to Dalapon, however, the latter may have a growth retarding effect even on the more tolerant species. Application of Dalapon to single leaves of bean plants, a sensitive broadleaved species, has shown that Dalapon may also be actively translocated through foliage to growing points of susceptible broadleaved plants.

Much has yet to be learned about the effect of environment, and condition of the plant on the efficiency of Dalapon action. The following observations may suggest variables that should be studied further.

1. The sensitivity of grasses to Dalapon appears to decrease with increasing age of the plant.

2. In some instances Dalapon appears to be less effective when applied to grass growing under dry soil conditions. Conversely it has often proved most effective when applied to actively growing succulent grass.

3. Northern or cool weather grasses, such as blue and quack, have been effectively controlled by early spring applications as well as by summer applications. Action may be quite slow when application is made during cool weather.

4. Early application to warm season species such as Bermuda and Johnson made before much new foliage has developed has not proven as effective as application made after considerable growth has occurred.

5. Seed stalk development of several grasses has been arrested or prevented by application in the early boot stage or before. The stalks may continue to elongate if application is delayed.

6. Dalapon is actively absorbed by roots as well as by foliage. Good results have been obtained from treatment of freshly plowed sod, however, soil applications require favorable soil moisture conditions for maximum activity.

Laboratory tests have shown that Dalapon does not translocate efficiently through dead tissue and any spray component that gives a quick kill of grass foliage may reduce its herbicidal efficiency. At high concentrations of Dalapon alone plants may show an immediate "burn" of foliage. This burn appears to be physiologically distinct from the

systemic growth regulator effect but may reduce systemic activity.

Although toxicological investigations are still underway it has been established that Dalapon has a low order of acute mammalian and fish toxicity. The compound has been found to have a short residual effect in soil.

Some Promising Applications

Results to date have indicated a number of desirable applications for Dalapon, however, further research is needed, under varying conditions, before the applications suggested in the following paragraphs can become general recommendations.

Railroads. Dalapon has been tested on several railroads and has been found to be very effective on grasses growing in ballast as well as on the berm. The nature of most roadbed vegetation is such that a grass killer alone will seldom answer the problem. When applied in combination with 2,4-D good general vegetation control has resulted at rates of Dalapon (sodium salt), varying from 25 to 50 pounds per acre. The higher rate has resulted in an appreciable degree of perennial grass kill, whereas the 25 pound rate has controlled annual grasses and given suppression of perennial grass growth. The 2,4-D component has given control of most non-grasses. Whether either component of such a mixture has an effect on the maximum efficiency of the other is a subject which will require further study.

Combinations of Dalapon with moderate rates of sodium chlorate have given good general weed control where mixed grasses and broadleaved species were involved. Further tests with this and other combinations involving Dalapon are indicated.

Dalapon will be commercially available in 1954 for railroad vegetation control in areas where experiments have established its merit.

Ditches. Wetting sprays of Dalapon (sodium salt) at concentrations as low as 10 pounds per 100 gallons have given practical control of a number of grasses, cattails and rushes growing in ditches or along their banks. 20 to 30 pounds per acre have given even better results.

Johnson grass on drainage or on irrigation ditches has been controlled for several weeks by the application of Dalapon (sodium salt) at 10 to 20 pounds per acre. Higher dosage has given considerable kill of roots and rhizomes. However, regardless of the dosage, the emergence of seedlings under moist conditions will often be such that more than one application per year will be needed.

Headlands and fence rows. Where grass control is desirable in such situations a spray of Dalapon (sodium salt) alone or in combination with 2,4-D for broadleaved weed control has shown promise. Dosage will depend on whether a kill or temporary control is desired. Application before seed stalks appear seems best.

Perennial grass in cropland. Further research is needed before a program can be recommended for any grass species. Rate and timing of application, and kind and frequency of subsequent tillage are all factors that must be considered. The possibilities of reducing grass vigor by close grazing or mowing early in the season and then spraying after some regrowth has taken place appears worthy of study. Limited tests have indicated that disking or plowing soon after application may reduce the effectiveness of a Dalapon application. However, in one experiment conducted by the writer on quack grass an early June spray of as little as 10 pounds of Dalapon (sodium salt) per acre followed by plowing one month later and one disking in August gave better than 85% control, as determined by mid-October examination.

Selective grass control in crops. Promising results have been obtained in the post-emergence selective control of certain annual grasses in the more tolerant crops including alfalfa, flax and beets. The chemical is not without effect on these crops and careful dosage, timing and yield studies will be required before recommendations can be made.

Other crops less tolerant of Dalapon such as cotton have been shown to tolerate a directed spray applied to wet the grass weeds with minimum wetting of the crop. When well established, even sensitive crops such as corn and sugar cane have tolerated such directed sprays in some experiments. Certain fruit crops including apples, pears and raspberries have shown adequate tolerance to Dalapon (sodium salt) to permit its use for grass control around the base of the plant, other tree species have been found to be quite sensitive.

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1. U. S. Patent 2,642,354.
2. Dalapon Bulletin Number 1. Published by The Dow Chemical Company, May 1953.

N-1 NAPHTHYL PHTHALAMIC ACID

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N-1 naphthyl phthalamic acid is a selective herbicide that has been included in weed control experiments during the past four seasons and was marketed in limited quantity in 1953. It has often been classed as a growth regulator but its type of action and selectivity are decidedly different from that of 2,4-D and closely related compounds. When applied to the foliage of sensitive species, it severely inhibits growth and causes epinastic responses but usually does not kill the plant. When used as a pre-emergence application, root growth of seedlings is greatly restricted, negative geotropism often occurs, and sensitive species either fail to emerge or show extreme stunting. In most experiments, therefore, it has given best weed control when applied to the soil surface before weed emergence.

N-1 naphthyl phthalamic acid is almost insoluble in water and has been used primarily as a wettable powder. The sodium salt is water soluble and has been tried in a few experiments. N-1 naphthyl phthalimide used as a wettable powder, is much less toxic to plant foliage than the acid or sodium salt formulations. In the soil the imide is slower in taking effect and weed control has been generally poor. However, mixtures of the acid and imide have sometimes given better results than the acid alone due apparently to a longer residual life. In other experiments the mixtures have

not performed as well as the acid alone when used at equal rates per acre.

The most extensive experiments with this herbicide have been conducted on cucurbits. Cucumbers, muskmelons and watermelons have shown good resistance to both pre-emergence and post-emergence applications under most conditions. The only cases of injury reported were in very early plantings when the soil was wet and cold and in a few experiments conducted during extremely hot, dry weather. Pumpkins and squash have shown somewhat less resistance than the other cucurbits and differential responses between varieties have frequently been reported.

Experimental results over a three year period have shown good weed control and no crop injury in the case of asparagus and with directed sprays on established nursery stock. Performance of this herbicide on cotton has been promising in the drier areas, notably Texas, New Mexico and Arizona, while in high rainfall areas it has caused injury. Promising results have also been reported in less extensive trials on soybeans, peanuts, gladiolus and for crabgrass control in turf. Results on lima beans have been variable. In the case of turf, treatments have been more effective when applied at a very high gallonage or when lightly watered-in.

Crops that are reported to be especially sensitive to N-1 naphthyl phthalamic acid include beets, spinach, parsnips, tomatoes, tobacco, strawberries and many of the crucifers. Sweet potatoes have usually been severely stunted by applications after transplanting but pre-planting treatments appear promising.

A large number of annual weeds have been selectively controlled in resistant crops. Among these are several annual grasses, pigweed (Amaranthus spp.), purslane (Portulaca oleraces), chickweed (Stellaria media), galinsoga (Galinsoga ciliate), lamb's quarters (Chenopodium Album), carpetweed (Mollugo verticillate), and ragweed (Ambrosia spp.). Weeds that have not been controlled include most established perennials, wild sunflower (Helianthus annuus) and smartweeds, knotweed and wild buckwheat (Polygonum spp.).

Effective rates of application have varied from 2 to 8 pounds per acre with the lowest amounts being used on light sandy soils. Results on muck or peat soils have been poor even at rates up to 12 pounds. As with most pre-emergence herbicides, weed control is greatly influenced by soil moisture conditions.

Its residual life in warm moist soil appears to be somewhat longer than for 2,4-D, averaging in general from four to six weeks. At least part of the normal amount of N-1 naphthyl phthalamic acid applied is retained in the soil surface even when severely leached. Heavy rains soon after application have therefore not destroyed its effectiveness. It has also been reported to remain active on the soil surface through periods of prolonged drought. The chemical has been shown to have a very low animal toxicity and no residues have been found in several crops from treated fields.

RECENT FINDINGS WITH 4-CHLOROPHENOXYACETIC ACID AND 3,4-DICHLOROPHENOXYACETIC ACID

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This topic was not given to me because I am an expert on the use of these chemicals. It was given to me because I would have access to the Research Report before this conference convened. I do not hesitate to state that I took advantage of that opportunity and what I say here will merely be my interpretation of data presented by others except for our own work on flax and leafy spurge.

Standardized abbreviated names have not been given either of these chemicals by our terminology committee. Therefore, several names are used for each chemical. 4-chlorophenoxyacetic acid has been called "4-C", "para" and "parachloro", while 3,4-dichlorophenoxyacetic acid has been called "3,4-D" and "DPA". We have so many lettered abbreviations to remember nowadays that I am inclined to use numbers wherever possible. Therefore, I shall refer to these chemicals as 4-C and 3,4-D.

4-C was tested on 20 species of weeds (mostly annual) and was tried on several crops including alfala, sweet clover, red clover, field peas, and flax. One report on each weed indicated that 4-C when mixed with other chemicals did not help in controlling quackgrass. Likewise, 4-C was less effective for controlling Canada Thistle than comparable rates of 2,4-D when rates ranged from 1 to 8 pounds per acre; 1- and 2-pound rates were also less effective than comparable rates of 2,4-D for controlling perennial sow thistle. Also a mixture of the esters of 2,4-D, 2,4,5-T and 4-C was less effective on leafy spurge than esters of 2,4-D.

One group of workers compared 4-C with 2,4-D and MCP for control of 14 species of annual weeds at 3 stages of growth. They used four experiments and showed that the amine of 4-C was consistently more effective than comparable rates of amines of MCP or 2,4-D for the control of tumbling mustard, shepherd's purse, flixweed, Russian thistle, red root pigweed, blue bur, tartary buckwheat, and purple cockle, while an ester of 4-C was superior to the same esters of 2,4-D or MCP for controlling red root pigweed and night flowering catchfly.

Another report indicated that the ester of 4-C was slightly more injurious to wheat than the amine, and that both forms were more injurious than 2,4-D or MCP. The same workers reported that 4-C was more toxic to field peas than 2,4-D or MCP when applied to peas that were 3 inches tall and 6 inches tall. They also reported that 4-C was more injurious to alfalfa, sweet clover and red clover seedlings than 2,4-D or MCP. Several other workers have obtained similar results on alfalfa. In all three reports 4-C was less satisfactory for controlling Russian pigweed, stinkweed and Russian thistle. It also has been very harmful to oats at low dosages.

Ladak alfalfa seedlings treated in the 2nd true leaf stage of growth with 1/8, 1/4 and 1/2 pound of 4-C per acre suffered a 26 to 30 per cent reduction in stand. This was about the same as for comparable rates of a 2,4-D ester and MCP ester, amine and sodium salt. Established stands of 2-year-old alfalfa were treated 1/4, 1/2, 1 and 2 pounds of 4-C amine per acre when alfalfa was 1 inch, 3 inches and 5 inches tall. As much as 1 pound of 4-C caused only slight damage to the alfalfa, especially at the 3-inch stage, but weeds were not controlled satisfactorily. Rates of ½ and 1 pound of 4-C amine per acre caused an abundance of floral abnormalities in alfalfa after being applied to an established stand that was 2-3 inches tall and 5 inches tall. An earlier application was less injurious. Therefore, it would be rather risky to use this chemical on seed fields.

Rates of 1½ and 3 pounds of 4-C amine and ester were applied pre-emergence to soybeans. The 1½ pound rate did not materially affect the stand, but the higher rate reduced the stand by 20 to 25%. 4-C was less harmful than a 2,4-D low volatile ester and about the same as MCP.

4-C ester, and 3,4-D amine and ester were compared with MCP amine, 2,4-D amine and 2,4,5-T amine on flax. One-fourth pound of 4-C per acre delayed flowering 7 days and a similar rate of 3,4-D delayed it 10 days. Both delayed the flax long enough to allow foxtail to take over. In four experiments these two chemicals consistently decreased flax yields more than MCP or 2,4-D and also gave poorer control of lamb's quarters and wild mustard.

In limited tests, 3,4-D has been effective for the control of yellow rocket, mustard, ragweed, lamb's quarters, rough pigweed and several woody species of plants. It has been especially effective for controlling bracken fern, but has been unsatisfactory for bull thistle.

Several workers have found 3,4-D to be less toxic to alfalfa, red clover, ladino clover and birdsfoot trefoil seedlings than 2,4-D, MCP, 2,4,5-T or 4-C, but it has been more injurious to peas. In one test 3,4-D was not superior to 2,4-D as a pre-emergence spray, but in greenhouse tests it has been more persistent than 2,4-D.

These data are not conclusive and do not warrant recommendations, but do indicate that these chemicals, may be used for specific weed control problems and should be investigated further.

ANALOGS OF 2,4 DICHLOROPHENOXYETHYL SULFATE

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Sodium 2,4 dichlorophenoxyethyl sulfate, also known as SES and CRAG Herbicide 1, is unique among herbicidal compounds in that it is relatively inactive when applied. Following its application to the soil, under favorable conditions it is converted to an active form, presumably, by soil microorganisms. In the active form in the soil, it kills germinating weed seeds as well as emerging weeds of many species. Because of these properties it should be applied following cultivation and before weed emergence. In repeated tests during the past five years SES has given comparatively good results as a means of controlling weeds in strawberries, raspberries, asparagus and a general line of nursery stock. It is being used in cultural practice by many growers of these crops. It has given varying results with respect to many annual vegetable and field crops such as corn, soybeans, onions, and snap beans. The most efficient rates of application of SES are 2 to 4 pounds per acre with the lower rates for coarse textured soils and the higher rates for heavier soils. SES is 90% active by weight, however, the rates are expressed in quantities of the 90% active material rather than acid equivalent. The effective period of herbicidal activity in the soil is 3 to 4 weeks under normal rainfall conditions, however, it has been found that it is effective in holding down weed growth for even longer periods if dry soil conditions follow the period of activation of the herbicide. It has also been noted that application of SES to the dry surface of a soil seemed to result in a delayed conversion to its active form during which time weed seeds at lower depths germinate without apparent injury from the herbicide. Rain falling on a dry soil within 2 to 3 days after application apparently aids the conversion in time to prevent weed growth or noticeably reduce the weed population. Another factor which seems to have caused variability in effectiveness of weed control with SES is soil temperature. In our work we have had less weed control in early spring than with summer and fall applications. Whether this is due to less activity of the herbicide at lower temperatures, reduced activity of soil microorganisms or other factors has not as yet been determined. There appears to be little, if any, drift hazard in the application of this chemical.

Several analogs of 2,4 dichlorophenoxyethyl sulfate have been synthesized and formulated. These analogs all have one biological property in common with SES in that they are applied following cultivation and prior to weed growth for most effective control of weeds. Chemically they are related to SES but differ through either hydrolysis or substitution in the side chain of the molecule or by the addition of chlorine to the phenol ring.

SESIN, which is 2,4 dichlorophenoxyethyl benzoate, is 50% active by weight and is most effective as a weed killer when applied at rates of 4 to 8 pounds per acre. This herbicide appears to have greater residual characteristics in the soil than SES and theoretically should require less frequent applications for effective weed control. Tests conducted at Ames, Iowa on strawberries in 1953 showed upwards of 95% control of annual weeds which was comparable to the results obtained with SES. However, information on the residual qualities of SESIN was not obtainable because of the long period of drouth which followed its conversion to the active form. During the drouth there was no continued germination of weeds in either the SES, SESIN or hand weeded check plots. Neither SESIN or SES were effective earlier in the season (July) when applied to the dry surface of the soil with no precipitation during the following two weeks. The application of SESIN at the rate of 8 pounds per acre to weed-free plots of Pfitzer Juniper cuttings, in irrigated transplant beds as late as June 3, did not appreciably reduce the weed stand as depicted by data recorded on July 22. Although the chemical was re-applied following cultivation and irrigation, control of both broadleafed weeds and annual grasses was poor during the remainder of the season.

Reports from other investigators indicate variable results both in weed control and crop response. In northern United States SESIN did not give as good weed control in soybeans, onions, and corn as 2,4 D ester, DNAP or chloro-IPC when applied during the month of May and resulted in decreased yields of soybeans and onions. In the East, SESIN gave only fair weed control in lima beans at 4 to 8 pounds per acre and caused severe injury to tomatoes. However, it looked better than SES on strawberries and asparagus.

NATRIN, Na 2,4,5 trichlorophenoxyethyl sulfate, is 90% active by weight. Suggested rates of application are the same as for SES. Comparative tests in evergreen transplant beds and established deciduous and evergreen material in the nursery row indicate that NATRIN, applied to either a surface-dry or a surface-wet soil, was apparently converted to the active state.

The ETHANOL form of SES, (50% active by weight) was as effective a preweed emergence herbicide as the liquid BENZOATE ester (35% active by weight) when applied to irrigated plots in June. In general, however, both the late spring and mid-summer applications of either chemical gave results which would not make their use commercially feasible at this time.

FENOX, bis (dichloro) phenoxyethyl oxalate, is 67% active by weight. This analog has not been widely tested, however, one investigator in northern United States reported generally ineffective weed control on corn and soybeans when applied in May, 1953.

The analogs of 2,4 dichlorophenoxyethyl sulfate applied prior to weed emergence offer potentialities as effective herbicides, commensurate to favorable climatic conditions. Observations on the effectiveness of these chemicals under variable climatic conditions point out the need for investigations on the relationship of weather and soil conditions to herbicidal activity.

AMINO TRIAZOLE

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Amino Triazole (ATA) has been under investigation to determine its possible uses as an herbicide. Most tests have been preliminary in nature and while results are somewhat variable, indications are that ATA may eventually become quite useful as an herbicide.

The following data on some characteristics of ATA may be of interest to workers considering the use of the compound. ATA has a molecular weight of 84.05 and is a white crystalline powder in appearance. It has a solubility of about 28 g. ATA per 100 g. water at 23 degrees C. and 26 g. ATA per 100 g. ethanol at 75 degrees C. It is insoluble in oils, ether or acetone. A chemical reaction of particular interest is the formation of ATA salts of phenoxy type herbicides which gives a single molecule composed of two herbicides. Toxicity tests indicate that ATA is relatively non-toxic to rats. If humans react in a similar manner, a person weighing 150 pounds could ingest 250 g. of ATA with no apparent toxic effects. The possibility of residual effects in soil was mentioned in one abstract which reported that residual toxicity to plants was evident in the soil 6 months after an ATA application of 6 pounds per acre had been made.

ATA is readily absorbed by roots and aerial parts of plants. Once inside the plant, it is translocated; mostly to the growing point and young tissues. Girdling experiments suggest that translocation of ATA applied to the aerial parts of plants is through the phloem tissues. Treated plants become chlorotic. Subsequent growth is often completely devoid of chlorophyll. Death of the plant may follow though this is not always the case. Often, the chlorotic tissues remain alive and eventually regain their normal green color. The development of chlorosis suggests that ATA disrupts the balance between plant processes involved in chlorophyll synthesis and destruction. Foliage applications of iron and nitrogen do not prevent chlorosis thus indicating that ATA does not act by typing up iron or nitrogen. The cotyledons, of ATA treated plants grown in the dark, green up when exposed to light but subsequent new growth is completely devoid of chlorophyll. This suggests that ATA may interfere with the formation of a chlorophyll precursor which was already present in the cotyledons at the time of treatment but was not synthesized in tissues produced after treatment. ATA inhibits shoot and root growth of seedlings. An accumulation of sugars in tissues produced after treatment and an increase in the plant respiration rate have also been noted following ATA applications.

In screening tests on crop plants, the selective toxicity of ATA was clearly evident. Oats, sorghum, sudan grass, kenaf, soybeans, vetch, peas, lima beans, cucumber and snap beans were quite tolerant to pre-emergence applications of 8 and 16 pounds of ATA per acre. Ladino clover, common millet, alfalfa, rape and birdsfoot trefoil, on the other hand, were susceptible to these pre-emergence applications. Sorghum, kenaf, and oats were more tolerant to 2 and 4 pound per acre post-emergence ATA applications than barley, flax, sugar beets, cotton, ladino clover, common millet, alfalfa, birdsfoot trefoil, rape and squash which were killed by the 2 pound rate of application. Other crops were intermediate in response in both pre- and post-emergence tests. Broad-leaf and weed control was excellent in pre- and post-emergence applications. Indications are that ATA is not as effective on grasses as on the broad-leaf weeds.

One report suggests that ATA may be quite effective in controlling poison ivy. Blackbrush and mesquite seedlings were injured but not killed by the application of 0.5 percent solutions of ATA in water. Mixtures of ATA and 2,4,5-T appeared to be more toxic to mesquite seedlings than 2,4,5-T alone. Similar mixtures applied to mesquite trees under field conditions have not been encouraging. The poor results obtained in the field test may have been due to inability to get the ATA in solution at the concentration used. Cut surface applications of ATA to oak have shown little promise. The control of whitebrush with ATA has also been unsuccessful.

In cotton defoliation work, ATA has shown some promise. As an additive to other defoliants, it acts as a synergist and regrowth inhibitor. When used alone, excellent defoliation and regrowth inhibition has been obtained in greenhouse studies at the Texas Agricultural Experiment Station. However, under field conditions results have been erratic. Apparently the effectiveness of ATA as a defoliant is dependent on growth and environmental factors not yet understood.

Several other possibilities for the use of ATA have been suggested. It may be useful as an additive to contact herbicides and herbicides such as CMU and phenyldimethylurea when they are used as soil sterilants. ATA aids by giving a rapid top kill not obtained when some of the soil sterilants are used alone. In some instances the ATA salts of 2,4-D appear to be more toxic to a plant species than 2,4-D alone but the opposite effect has also been noted. That is, some ATA salts of 2,4-D were not as toxic to some plants as 2,4-D alone. It is possible that the combination of ATA with 2,4-D may change the selective toxicity of 2,4-D so plants that are tolerant to other 2,4-D formulations might be susceptible to the ATA-2,4-D compounds.

It seems certain from the limited data available that ATA is a potent new herbicide. ATA alone, in mixtures with other herbicides and as salts of phenoxy acids should be investigated for possible uses in all phases of weed control work.

CERTAIN USES OF UREA HERBICIDES

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Many of the herbicidal uses of CMU were discussed here at this meeting or were reported in the research abstracts. Our main contribution to the discussion of the herbicidal uses of CMU that we can make is a summary of some of the data we have obtained on the longevity of weed control resulting from applications of CMU at soil sterilant rates. Since it is impossible to discuss in the few minutes allotted all of the data we have obtained on this subject, we will confine our remarks to a few of the older tests which have been conducted in the Midwest. We have selected three experiments, the results from which are quite typical of those we have obtained.

One of the tests of interest was on Johnson grass in southeastern Kansas, applied on June 13, 1951. Eradication of the original infestation was quite efficient as shown by observations after 4 months. (See Table 1). Observations 24 months after application showed that treatments of 60 pounds per acre and above were still providing good weed control. (Table 2).

Table 1. Percent Control of Johnson Grass after 4 Months

Table 1. Percent Control of Johnson Grass after 4 Months

CMU Weed Killer Lb./A., active	
40	60
60	98
80	100
100	100

Table 2. Percent Control of All Weeds, Johnson Grass Area

CMU Weed Killer Lb./A., active	12 Months	24 Months
40	50	15
60	100	90
80	100	100
100	100	100

When these plots were inspected in June, 1953, it was felt that they might be hard to locate. Such was not the case, however, as it was noticed that the treated plots could be seen from about a quarter of a mile distance.

Another test which is of interest is one which was started here in Kansas City on April 13, 1951. Observations on weed control after 4, 8, 15 and 18 months are shown in Table 3.

Table 3. Percent Control of All Weeds; Infestation Mostly Annuals. On Cinder Ballast

CMU Weed Killer Lb./A., active	Months after treating 4	8	15	18
20	100	99	50	0
40	100	100	98	50
60	100	99	99	75
80	100	99	98	80
100	100	100	99	99

From this table it is seen that CMU provided good weed control throughout the first season at 20 pounds per acre, but on this porous medium provided no better than fair control at the end of the second season at 40 and 60 pounds per acre. Follow-up treatment was obviously indicated for 1953, the third season. The lowest rate used as a re-treatment was 8 pounds per acre. Complete weed control for this season was obtained. Once perennial weeds have been eradicated in an area the amount of CMU required to maintain complete weed control for one season is usually about 8 pounds per acre.

One other illustration of the longevity in weed control by CMU will be given. This is on silt loam soil, treated October 18, 1950. The original infestation was field bindweed. Excellent control of this weed was obtained as shown in Table 4.

Table 4. Percent Control, Field Bindweed; Silt Loam Soil

CMU Weed Killer Lb./A., active	Months after treating 10	24	36
20	65	50	*
40	40	100	100
80	95	100	100
160	65	100	100

* Trace present

Table 5. Percent Control, All Weeds; Silt Loam Soil

CMU Weed Killer Lb./A., active	Months after treating 10	24	36
20	55	75	0
40	65	80	50
80	95	92	70
160	99	96	70

It is apparent from Table 5 that some weeds become established in the third season from these treatments. In order to test the response of cultivated crops half of each plot was spaded and planted to corn, sorghum, and tomato transplants on May 26, 1953. Injury ratings made on August 1 are shown in Table 6.

Table 6. Injury to Crops, Third Season after CMU Treating Silt Loam Soil

CMU Weed Killer Lb./A., active	Corn & Sorghum	Tomato
20	0	0

40	0	1
80	0	4
160	4	4

Injury scale: 0 = None; 1 = Slight; 2 = Moderate; 3 = Severe; 4 = Death

Slight injury to tomato was noted at the 40 pound per acre rate.

Another compound, closely related to CMU, is 3-(3,4-dichlorophenyl)-1,1-dimethylurea. Its activity resembles that of CMU, being different in that in areas of moderate to high rainfall, applications of rates equivalent to those required with CMU have provided good sterilant type weed control for longer periods than does CMU Weed Killer. It has also been demonstrated that 3-(3,4-dichlorophenyl)-1,1-dimethylurea can be used successfully at rates of 1 to 1.5 pounds per acre as a pre-emergence treatment on certain crops. This new chemical is available to investigators.

Another member of the urea herbicide family, which we have been investigating for about four years, and one for which quite a different use is anticipated, is phenyldimethylurea. Data we have obtained on the application of this chemical at devegetant rates indicate that it will find particular usefulness as a control agent for deep-rooted perennials. Since its herbicidal effects are gone after a relatively short period of time, it appears to be particularly advantageous for the control of perennials in crop areas. Further experiments obviously must be run in order to determine the specific action of phenyldimethylurea on the various important deep-rooted perennials.

RECOMMENDATIONS OF THE RESEARCH COMMITTEE OF THE N.C.W.C.C.

The following suggestions and recommendations are derived from the best information accumulated through 1953, by the Research Committee of the North Central Weed Control Conference. The committee recognizes that many factors, which vary from region to region, have a pronounced effect upon the results obtained from application of herbicides. Therefore, this report can in no way replace state and local recommendations and specific recommendations should be obtained from your state agricultural experiment station, extension service or regulatory officials.

The rates of application given for 2,4-D, MCP, 2,4,5-T and TCA refer to acid equivalent, whereas, rates of PCP, DNBP, and DNAP refer to phenol equivalent and rates of PMA, IPC, CIPC, CMU, MH, SES, NP, and KOCN refer to active ingredient. Recommendation of chemicals is subject to approval by Pure Food and Drug Administration.

Control of Perennial Weeds

Quack or Couch Grass (Agropyron repens L.). For other than small patches, cultivation will be found the most practical means of eradicating quack. Intensive cultivations should commence during the summer months. Where soil erosion or leaching is not a problem this to be followed by a black summer fallow. Follow-up cultivation may be necessary. In excessively wet years only very poor control can be effected. Heavy pasturing and/or heavy fertilization of quack prior to initiating cultivation will facilitate eradication.

Two methods of cultivation are practiced: the use of a disc implement to shred the rhizomes and induce starvation by growth; the use of a cultivator with spring teeth, preferably followed by a cable or rod-weeder to bring the rhizomes to the surface where they will dry out and die. In either case the operations may be intensive and continued over a long enough period to free the soil of all viable material. The method employed would seem to depend on soil type, regional conditions and availability of tillage implements. If the infestation is in scattered patches the disc may be best implement for rhizomes will not be dragged to clean parts of the field.

Patches of quack can be eradicated with chemicals. Sodium chlorate may be applied any time, though possibly best in the fall at 3 to 5 pounds per square rod (500 to 800 pounds per acre). TCA is best applied in the fall and is effective at 80 to 100 pounds per acre on undisturbed sod and at 25 to 70 pounds when combined with thorough cultivation, such as that given by plow, one-way disc or spring-tooth cultivator. In drier areas cultivation prior to chemical application seems more effective than that succeeding. Complete kill of the quack grass rhizomes may not be achieved; therefore, follow-up cultivation or chemical application are often needed. In sub-humid regions the residual effect of late summer or autumn applications can be expected to extend into the growing season following treatment.

CMU may be used for eradicating quack on non-crop land. Early spring or late fall applications seem most effective. Complete to almost complete kills are obtained by 20 to 40 pounds per acre. Cultivation does not seem to enhance its killing action. At over 20 pounds, normal development of crop plants is prevented for at least 2 years. Effective temporary suppression of quack may be secured by early spring foliage applications of from 4 to 8 pounds per acre of MH followed 3 to 6 days later by plowing and working down. Crops sown thereon do not seem affected.

Johnson Grass (Sorghum halpense L.) Clean cultivation appears to be the most practical method of controlling extensive infestations of Johnson Grass. Heavy pasturing, frequent clipping or a combination of the two will reduce stands of Johnson grass. Chemicals are recommended for non-cultivated land and for spot treatment in fields. Effective herbicides include sodium chlorate, TCA, CMU, and boron-chlorate mixtures. Rates required vary with location and field conditions. Recommendations are 3 to 5 lb. sodium chlorate per sq. rod (480 to 800 lb. per acre), 60 to 100 lb. TCA per acre and 40 to 80 lb. CMU per acre, and a 3 to 1 boron-chlorate mixture at 6 to 9 lb. per squ. rod (960 to 1440 lb. per acre).

Canada Thistle (Cirsium arvense L.) and Perennial Sow Thistle (Sonchus arvensis L.) Intensive cultivation and winter wheat or rye has proved to be an effective method of controlling Canada and perennial sow thistle. The area should be plowed in the spring (early in dry springs and areas, but when budding in wet springs or areas), and cultivated with a duck-foot field cultivator or one-way disc, every three weeks until fall when the crop is seeded. After the crop is harvested, the process is repeated. Two and possibly three years will be required to eliminate these weeds. One year (from spring to freezeup) of intensive cultivation can be used to eliminate a high percentage of the thistles in areas where erosion is not a problem. A short period of intensive cultivation followed by a good crop

of alfalfa or perennial grasses will eliminate a high percentage of the thistle in three years. Likewise, a good summer smother crop, such as close drilled soybeans, sudan grass, or millet, when preced and followed by intensive cultivation, will give good control in two or three years. Late fall plowing just before freezeup will be found helpful.

2,4-D is more effective than MCP or 2,4,5-T on these thistles. Sow thistle is somewhat more readily controlled than Canada thistle. Usually at least two applications of 2,4-D each year over a period of two or more years are necessary to eradicate these weeds. The first application each year should be made at the bud stage, and one or more later treatments made in the summer and/or early fall when the resprouting thistles are in the rosette stage. Rates over 1 pound per acre tend to be progressively less effective. Good control has been obtained by treating infested areas with 2,4-D once or twice and subjecting the area to plowing and intensive cultivation as soon as new growth appears.

Sodium chlorate gives good control at 3 to 5 pounds per square rod (500 to 800 pounds per acre), though retreatments following cultivation are usually needed for eradication.

Leafy Spurge (Euphorbia esula L.) For extensive infestations on arable land, intensive cultivation alternated with cropping will in time bring even the most persistent stands under control.

2,4-D applied at the maximum rate the crop will tolerate will delay and often prevent the plant from developing seed. Repeated applications of 2,4-D to infestations on grass-land, while seldom eradicating leafy spurge, will reduce the stand, often quite considerably.

For small and scattered patches, and for infestations on non-arable land where it is necessary and advisable to eradicate this weed, the soil-sterilant herbicides are recommended. Sodium chlorate and boron-chlorate mixtures, applied initially at approximately 5½ lb. per square rod (880 pounds per acre) or boron compounds at 5 to 6 lb. of boron trioxide per square rod (800 - 960 lb. per acre) and followed up by lighter applications to eradicate stray or surviving plants, are being widely and successfully used.

For extensive infestations on non-arable land, close pasturing with sheep over several years will be found effective.

Russian knapweed (Centaurea repense L.) and Hoary Cresses (Cardaria spp.) Where soil type and topography permit, duckfoot cultivations at two-week intervals will prvent seed production and reduce the stand. Seeding to winter wheat or rye, followed by cultivations after harvest will also give satisfactory reductions after 2 to 3 years. Where possible a control program should make use of the combined beneficial effects of crop competition and intensive cultivation.

2,4-D at ½ to 1 pound per acre will control top growth of hoary cress in growing crops when applied at the bud stage. Retreatment of fall rosettes at 1 to 2 pounds will give substantial stand reductions. Such a combination of treatments should give almost complete elimination after 2 or 3 seasons. Russian knapweed is more tolerant to 2,4-D. A rate of 1 to 2 pounds 2,4-D is needed to stop top growth and prevent seed production. Only slight stand reductions can be obtained from repeated foliage applications.

Soil sterilants should be used to eliminate small patches or scattered individuals which remain after some of the above treatments have been used. Sodium chlorate at 4 to 6 pounds per square rod (640 to 960 pounds per acre) can be used for either species, using the higher rate on Russian knapweed. Use the boron compounds at 10 to 15 pounds per square rod (1600 to 2400 pounds per acre). Use the mixtures of boron-chlorate at 8 to 10 pounds per square rod (1280 to 1600 pounds per acre). On non-crop land CMU at 40 and 60 pounds per acre can be used for hoary cress and Russian knapweed respectively. Seedlings can be controlled with 2,4-D foliage sprays, by cultivation or by seeding to a close growing grass or crop.

Field Bindweed (Convolvulus arvensis L.) Control may be accomplished by intensive cultivation accompanied by growth of a smother crop. Cultivation to cut off all plants about 4 inches below the surface should be repeated 8 to 10 days after emergence. After the plants have been weakened by this treatment a smother crop should be substituted for the cultivation to reduce erosion and yield some returns from the land. Alternate cultivation and smother crop should be repeated until elimination of the weed has been achieved. Two to four years are required for eradication in the Great Plains area.

Application of ½ to 1 pound of 2,4-D per acre in late fall or in bud to bloom stage are effective. This treatment usually must be repeated for a satisfactory kill and control of seedlings. Small patches may be killed by the use of soil sterilizing chemical. An application of 4 to 6 lb. per sq. rod (650 to 1,000 lb. per acre) of dry sodium chlorate followed a year later by spot treatment of any scattered plants that may be left is a practical method for small areas. CMU and certain boron compounds are suitable for locations where the effect on the soil is not objectionable. CMU may be applied at rates of 0.4 to 0.6 pounds per square rod in two to four gallons of water (64 to 96 pounds in 320 to 640 gallons of water per acre). Dry unrefined borax should be applied at the rate of 10 to 11 pounds of boron trioxide equivalent per square rod (1600 to 1760 pounds per acre). When a soluble form of borate is used it should be applied either dry or as a spray at the rate of 7 to 10 pounds of boron trioxide equivalent per square rod (1120 to 1600 pounds per acre). Mixture of soluble borate and sodium chlorate may be used also. A two to one mixture should be applied at the rate of 8 to 10 pounds per square rod (1280 to 1600 pounds per acre). Any surviving weeds should be retreated, beginning the second spring after original treatment, until eradicated.

Toadflax (Linaria vulgaris Hill.) On good crop land a system of alternate fallow and cropping to a cereal grain has reduced the stand of toadflax sufficiently to permit successful crop production. The fallow must be cultivated intensively. Fall tillage with a disc-type machine to cut off seedlings or sprouts from old roots in the year preceding the fallow is very important. In the fallow year, shallow tillage with a duckfoot cultivator and rod weeder should be given at sufficiently frequent intervals to prevent regrowth from appearing above ground for more than 5 to 8 days. This means at least 8 to 10 operations in one season. If wind erosion is a serious factor the land should be worked in alternate strips of fallow and crop, the strips not more than 16 rods wide or a rotation of intensive tillage of fallow and fall rye should be adopted.

Seeding down to grass after the land has been intensively fallowed the previous season and repeated spraying with 2 pounds per acre of 2,4-D ester has been effective in reducing the stand and vigor of this weed.

Soil sterilants can be used economically to eradicate small patches. CMU at 64 pounds per acre, sodium chlorate or boron-chlorate mixtures each at 10 lb. per sq. rod (1600 pounds per acre) have given satisfactory control. Residual effect tends to be longer when CMU is used.

Other Perennial Weeds. Bur ragweed (Franseria tomentosa) and (Franseria discolor) may be very effectively controlled by an application of 2,4-D ester at the rate of 2 pounds per acre in the actively growing or pre-bud stage. The treatment must be made in the pre-bud stage.

Sodium chlorate at 4 pounds per square rod (640 pounds per acre), soluble borate and borate-chlorate mixture, each at 6 pounds per square rod (960 pounds per acre) and CMU at 60 pounds per acre will give very satisfactory kills, but because of cost their use would be limited to small patches.

Poverty weed (Iva axillaris) can be controlled but not eradicated by spraying with 2,4-D ester at a dosage of 2 pounds per acre in the bud stage of growth. CMU at 20 pounds per acre has given almost complete eradication.

Orange hawkweed (Hieracium aurantiacum) and Tansy (Tanacetum vulgare) can be readily controlled by spraying with 2,4-D ester at 2 to 3 pounds per acre in the bud to flowering stages and repeating the treatment in September.

Buttercup (Ranunculus acris) can be readily controlled by spraying with 2 pounds of MCP amine in the spring when the weed is flowering.

Control of Woody Plants

Most woody plants can be effectively controlled with the ester formulations of 2,4-D or 2,4,5-T. Therefore, when treating mixed species, mixtures containing equal parts of these two herbicides may be used. These selective herbicides are usually effective when applied in sprays to the foliage, to basal bark, or to cut surfaces. Ammonium sulfamate is effective for killing woody plants where selectivity is not a factor.

The soil-sterilant type chemicals such as CMU, borax and sodium chlorate are often valuable in killing woody plants where the entire vegetation is to be destroyed.

It should be borne in mind that for most woody plants repeated applications are necessary and often a different method should be chosen for the second spray. The way these chemicals are applied to woody plants is very important. Timing of sprays, volume of solution, concentration of chemicals and environmental factors will often affect the results.

Brush control recommendations will vary depending upon the type of brush control problem and whether the objective is control or eradication.

For details as to the chemical best suited for a specific species consult qualified local agricultural authorities.

Rangeland and Pastures. The chemical control of brush and trees on ranges and pastures should be followed by a management program which will insure prompt recovery of desirable grasses and native legumes and thus aid in preventing sprout regrowth.

The growth regulator herbicides and ammonium sulfamate are the most practical to use in controlling brush and trees on lands suitable for range and pasture development.

Foliage Sprays (ground equipment). Woody plants sensitive to either 2,4-D or 2,4,5-T may be treated by wetting the foliage with sprays containing at least 3 pounds of acid as an ester per hundred gallons of water.

Ammonium sulfamate at a concentration of at least 3/4 pound per gallon of water is effective as a foliage spray on mixed brush. The addition of a spreader-sticker to ammonium sulfamate is advisable.

Buckbrush may generally be controlled by repeated applications of one to two pounds 2,4-D ester per acre applied during the late spring to early summer as soon as plants get fully leaved. However, geographical locations as well as variation in species and varieties may cause variations in results.

Prickly pear cactus and yucca are killed with a wetting spray containing 0.75 to 1 pound of 2,4,5-T ester emulsified in one gallon diesel oil and 4 of water, or 5 gallons of oil. This solution is most effective on yucca when applied in April, May or June and on prickly pear in September.

Aerial spraying of dense stands of post oak, blackjack oak and associated species to obtain grass production will usually require 2 pounds of 2,4,5-T ester (low volatile preferred) in 5 gallons of spray per acre as an initial treatment. Retreatments, using 1 to 2 pounds of this herbicide per acre, will generally be necessary to develop maximum pasturage. These species may also be controlled with 2,4-D and 2,4,5-T ester mixtures, using 3 pounds total acid per acre for the first treatment, followed with retreatments with 1 to 2 pounds per acre in subsequent years. Oil in water emulsions, such as 1:4, give larger droplet size than commonly used oils and thus drift hazard is reduced.

Shinnery oak may be effectively controlled with low volatile 2,4-D ester at 1 pound per acre in 5 gallons of diesel oil or in an emulsion of 1 gallon of diesel oil and 4 gallons of water applied in aerial treatments. This application should be made for 3 consecutive years to obtain maximum control.

Mesquite has usually been successfully controlled with 0.50 pounds per acre of low volatile 2,4,5-T ester in a single airplane application.

The best time to apply foliage sprays on the oaks and mesquite is at full leaf and during the 3 to 4 week period thereafter, providing soil moisture conditions were sufficient for active growth prior to time of spraying.

Sand sage is controlled with 2,4-D ester at 1 pound per acre. The most effective period for spraying sand sage is during the period when plants have 6 to 8 inches of new growth.

Basal-Bark Dormant Treatment. Basal-bark and ground line treatments are good control measures

on trees less than 6 inches in diameter. Concentrations ranging from 8 to 16 pounds of the low volatile 2,4,5-T ester per hundred gallons of diesel fuel are recommended for most species. On some species such as cottonwood and willow, 2,4-D esters are suitable. The entire basal area at the ground line completely encircling the plant should be wetted to the point of runoff. The most effective time of application for most hardwoods is from December 15 to March 15th.

Cut Surface Treatment. Generally frilling or cutting followed by treating, are advantageous in controlling larger trees. Many species of trees may also be killed by applying the same chemicals for basal-bark treatment to freshly cut surfaces of frills and cups in standing trees. Stumps should be sprayed sufficiently to permit some of the solution to run off onto the soil. Ammonium sulfamate applied as crystals or as a concentrated water solution (4 to 6 pounds per gallon) is effective in preventing sprouting of stumps.

Roadsides, Utility Lines, and Other Rights-of-Way

Effective chemicals for the control of woody plants on rights-of-way are 2,4-D and 2,4,5-T alone and in combination, and ammonium sulfamate. Mixtures of these 2,4-D and 2,4,5-T are useful when mixed stands of woody plants are to be controlled.

Foliage Sprays. Woody plants sensitive to 2,4-D and 2,4,5-T should be treated using a wetting foliage spray containing at least 3 pounds of 2,4-D and 2,4,5-T per hundred gallons of water. Low volatile ester brush killers containing 2,4-D and 2,4,5-T are suggested where mixed species are encountered. Ammonium sulfamate at a concentration of at least 3/4 pound per gallon of water is effective as a foliage spray on mixed brush. The addition of a spreader-sticker to ammonium sulfamate is advisable. Aerial spraying on utility rights-of-way and roadsides is still in the development stage.

Basal Sprays (dormant and active growth period). Basal sprays with 2,4-D and 2,4,5-T properly applied are usually more effective on the more resistant species than are foliage sprays. Smaller trees, usually under 6 inches in diameter are most responsive to this method. Applications of 2,4,5-T or mixtures of 2,4-D and 2,4,5-T at rates of 8 to 16 pounds per hundred gallons of oil have proved effective. It is most important to spray the entire basal area of all stems to the point of run-off. Volume of spray with this method is most important.

Stump Treatment. In areas recently cut, as in the case of new right-of-ways or where dead standing trees are objectionable as along highways, the cut plants may be effectively treated by using 2,4,5-T or mixtures of 2,4-D and 2,4,5-T at rates of 8 to 16 pounds of acid equivalent per hundred gallons of oil. The material should be applied to the stump so as to completely wet the top and sides of the stump to ground level. All exposed roots should be sprayed. Sufficient volume is most important with this method. Ammonium sulfamate applied as crystals or as a concentrated water solution (4 to 6 pounds per gallon) is effective in preventing sprouting of stumps.

Forests, Forest Plantations, and Farm Woodlands

Chemicals may be useful in several ways in connection with controlling undesirable woody plants on forest, plantation, and woodland areas. They are effective in reducing competition by brush to desirable coniferous regeneration. They can be used in connection with preplanting site preparation of areas to be planted to forest plantations. They can also be used in release operations in sapling stands and in the improvement of the composition of older stands. In many of these applications a goal of temporary control rather than permanent eradication of the woody weeds may be adequate in obtaining the desired objectives. This may reduce costs of treatment to those justified by the relatively low per acre product values involved. Foliage sprays, cut surface and basal applications are all useful under certain conditions.

For purposes of freeing coniferous regeneration from brush competition, foliage sprays containing two pounds of ester formulations of 2,4-D or 2,4,5-T, per hundred gallons of spray, are recommended. Where the brush consists of hazel, willows or alder, 2,4-D is adequate. For the control of blackberries, raspberries, cherry, thornapple, ash, osage-orange, basswood and maple 2,4,5-T is more effective. For mixed brush populations, mixtures of 2,4-D and 2,4,5-T are recommended. Foliage applications should be made after the leaves have attained full size and before their activity has been reduced in late summer. Such applications, properly made, will usually be effective in reducing competition to coniferous seedlings for 3-5 years. Where control for a longer period is necessary, repeat sprayings are recommended.

Where brush control is necessary prelimary to the planting of trees for forest plantations, foliage treatments using 2,4-D, 2,4,5-T, or ammonium sulfamate can be used. If natural regeneration of conifers are present on the area, 2,4-D or 2,4,5-T should be used exclusively to avoid killing the conifers.

Chemical treatment can be useful in releasing established plantations from overhead competition and in eliminating poorly formed individuals or inferior species from sapling or pole-sized forest stands. For this purpose cut surface treatments in frills or cups as well as basal applications are recommended. Esters of 2,4,5-T in oil solutions at concentrations of 8 to 16 pounds of acid per hundred gallons of oil are recommended for both cut surface and basal types of application. Ammonium sulfamate as a dry salt or as a concentrated water solution (6 to 9 pounds per gallon of water) can be effectively applied to cut surfaces of stumps, frills or cups to prevent resprouting of most species of woody plants. The addition of a sticker or spreader to such water solutions may be necessary.

Alternate Hosts

Barberry - alternate host of stem rust of wheat, oats, barley, and rye. European barberry is killed by common salt applied around base of plant; but ammonium sulfamate applied to cut surface of cane stubs at the ground line or sprays containing 14 pounds MCP ester in one hundred gallons of oil and a combination of 2,4-D and 2,4,5-T plus PCP applied as a basal spray, with special emphasis on the ground line. To kill Colorado barberry (Berberis fendleri), 2,4-D ester in both the foliage and dormant stages with 1.6 ahg water emulsion and 12 pounds ahg oil solution, respectively, is recommended. Allegheny barberry is killed in both the foliage and dormant stages by 12-14 pounds ahg oil solution of a combination of 2,4-D and 2,4,5-T esters plus PCP.

Ribes--currants and gooseberries--alternate host of white pine blister rust. Basal treatment with 14 pounds of 2,4,5-T ester in one hundred gallons of

oil is recommended for killing upland ribes, namely: R. cynosbai, R. missouriense, and R. americanum. The latter species of ribes also is killed in both the foliage and dormant stages with 1.6 pounds of 2,4-D ester in one hundred gallons of oil, respectively.

Red Cedar - alternate host of apple, pear, and quince rusts. These trees may be killed with common salt (sodium chloride), sodium chlorate, and possibly other soil sterilants applied at the ground line. A foliage wetting spray of 3/4 pounds ammonium sulfamate per gallon of water is also effective.

Shrubs Poisonous to Touch

Poison Ivy--(Toxicodendron or Rhus spp.). Two pounds of 2,4,5-T ester in one hundred gallons of a water emulsion applied as a foliage spray is recommended. The whole plant should be sprayed with special emphasis on the ground line and surrounding soil. Dormant spray of 12 pounds in one hundred gallons of oil also may be used. Ammonium sulfamate, sodium chlorate, or borax formulations dissolved in water (1 pound to a gallon) and sprayed on poison ivy to a point of thorough wetting of foliage and surrounding soil also have been used effectively.

Poison Sumac--(Rhus vernix). Due to the height of this shrub and danger of skin poisoning, treatment with either a growth regulator, ammonium sulfamate or a soil sterilant type of herbicide in the dormant rather than the foliage stage is recommended.

Weed Control in Field Crops

Spring Sown Grain. Wheat and barley are less sensitive than oats to 2,4-D applications made during the growing season. Wheat is less sensitive than barley. All three crops are sensitive as seedlings, from emergence to the 2-leaf stage. Wheat and barley are relatively tolerant after reaching 5 full leaves until the early boot stage. During this period 1/4 to 1/3 pound ester or 1/2 to 2/3 pound amine salt of 2,4-D can usually be used to control broad-leaved weeds without injury to the crops. Avoid spraying wheat and barley in the boot or shot blade stage of development.

Some injury to oats should be expected from spraying any time from seedling to early boot stages of growth, with the time of jointing apparently the most sensitive. Weed control generally will more than offset losses resulting from 2,4-D injury, however. Applications of 2,4-D (see rates for wheat and barley) made from early boot on through heading are generally safe with some yield depressions resulting from treatment at the early boot stage. Oats are more tolerant of MCP than of 2,4-D, permitting the use of 1/2 pound per acre. Susceptibility of the weed population should be known before using MCP.

In general, during seasons when growing conditions are not optimum due to drouth or cold weather, use the upper limits of the range of rates given. Likewise, when growth rate of weeds and crops approaches maximum the lower rates can be used. If there is occasion for pre-harvest treatments, as much as 1 pound 2,4-D ester may be applied at any time after the milk stage without appreciable injury to the crop. Contact herbicides can be used to give more rapid drying of weeds where treatment has been delayed until near harvest time.

Varietal differences exist, but local research agencies should be consulted for specific information.

Fall Sown Wheat. Winter wheat may be treated with 2,4-D in dosages sufficient to control most annual broad-leaved weeds with little injury to the crop if applied in the spring from the fully tillered through the jointing stages of growth. From 1/4 to 1/2 lb. of 2,4-D acid equivalent to the acre as an ester or up to 3/4 lb. as an amine are suggested dosages. Similar applications made in the fall usually result in damage to the crop and are not recommended. Pre-harvest treatment applied when the wheat is in the milk to hard dough stage should be looked upon as an emergency measure to be used only when weeds threaten to interfere seriously with harvesting. A dosage of 1 pound 2,4-D to the acre is usually required at this stage and may result in damage to the crop. Weed control at this stage is often not satisfactory.

Weeds and weedy grasses which are resistant to 2,4-D may best be controlled by proper pre-seeding cultivations and crop rotations.

Flax

Cultural Practices. Weeds are generally more of a problem in flax than in small grain, therefore, growers should sow flax on relatively clean land. Early after-harvest tillage of small grain stubble to control perennial weeds, prevent weed seed production, and stimulate annual weed seed germination in late summer and fall is a recommended method of preparing land for flax the following year except where after-harvest tillage results in serious wind erosion. Preventing weed seed production in corn, soybeans, and other cultivated crops, followed by surface tillage in preparing the seedbed for flax is desirable weed control practice. Delayed sowing of flax to permit spring tillage for wild oat control has been successful in some areas, although sometimes detrimental to the flax. For delayed sowing, early-maturing varieties such as Sheyenne or Marine are generally recommended.

Herbicides. Flax should be sprayed with MCP or 2,4-D as soon as there is sufficient emergence of susceptible weeds to make spraying practical. Spraying may reduce yields of seed and straw unless weed competition is reduced sufficiently to offset injury from spraying. MCP is less likely than 2,4-D to injure flax and is therefore the preferred material. Use 2 to 3 ounces per acre of MCP or 2,4-D in amine formulations for susceptible weeds like wild mustard. Use 4 ounces for lamb's quarters, pigweed, stinkweed, cocklebur, marsh elder, and ragweed. For moderately resistant weeds, spot spraying at heavier rates may be necessary. Use MCP at 5 to 6 ounces per acre to prevent seed production by Canada thistle. Use 2,4-D ester, at 3 ounces per acre to control Russian pigweed and Russian thistle.

TCA at 5 pounds per acre will kill green foxtail, yellow foxtail, giant foxtail, and barnyard grass in young flax. The flax should be at least 2 inches tall and the weeds less than 2 inches for best results. TCA can be applied in mixture with MCp or 2,4-D to kill susceptible grass weeds and susceptible non-grass weeds with one application.

Corn

Spraying with 2,4-D can be used to reduce the number of cultivations needed and to control some weeds in the row or hill. It should not be expected to replace cultivation because weeds not controlled by 2,4-D will be given an opportunity to develop. Cultivation is needed regardless of weeds on some soil types.

Post-emergence. Spraying should be timed to give complete and early control of the weeds. Some injury to corn may result from 2,4-D spray treatments made during the period from emergence to tasselling. Brittleness and bending or breakage of stalks is the most serious type of injury, and it may result in severe stand losses when followed by a storm or cultivation. Several factors influence the degree of injury to corn resulting from 2,4-D treatments. At the rates of application commonly used for weed control in corn during the period of emergence to tasselling, it is probable that the morphological stage of growth at which 2,4-D treatment is made is less important than the effects of environmental factors on the response of the corn to the 2,4-D except the period extending from two weeks before silking until the silks are dry. Severe reduction in seed set may result from 2,4-D treatments made during this period, regardless of growing conditions. Corn developing under optimum conditions for growth is more susceptible to 2,4-D injury than corn developing under less favorable growth conditions. Hybrids and varieties vary in their susceptibility to 2,4-D, but differences are not important at rates below 1/2 pound per acre. Inbred lines vary more widely and single-cross seed fields should not be sprayed except in an emergency, or on inbreds of proven tolerance, and then at minimum rates. Rates of 1/4 to 1/2 pound per acre have proven satisfactory; the esters must be used at lower rates than the amines. Lower rates are safer and should be used whenever the danger of corn injury is great, or when very susceptible weeds are to be controlled. Up to 1 pound may be used for resistant weeds with probable injury to the corn.

If spraying must be done at any time when the corn is large enough to put the spray under the top leaves by means of drop nozzles, this should be done unless the weeds are taller than the corn. The spray must strike the tops of the weeds to be most effective.

Pre-emergence. In most of the area pre-emergence with 2,4-D will control annual grasses and some tolerant broad-leaved weeds such as purslane, which are not controlled well by post-emergence sprays. .On loam soils and those of finer texture, pre-emergence use of 2,4-D is satisfactory if applied before emergence at rates of 1 to 2 pounds per acre. The ester formulations are less hazardous to the corn than amine salt formulations. Dry weather after pre-emergence treatments may make them ineffective and excessive rain creates a hazard to the corn. One pound per acre may not control all weeds but is often more economical, considering cost of materials. The effectiveness of pre-emergence herbicide treatments is greatly increased when the remaining stunted weeds in the hill or row are covered by follow-up cultivations. Soils high in organic matter will require larger dosages than soils low in organic matter. Pre-emergence applications are not recommended on sandy soils. An application of 2,4-D at pre-emergence rates, on the soil and bases of the corn stalks only, just after the last cultivation may prevent the emergence of weeds which otherwise might interfere with harvest. Bending of the stalks at the lowest nodes may follow this treatment.

Sorghums

The use of 2,4-D for weed control in sorghums is recommended only when weeds cannot be controlled by cultivation. Sorghums are more tolerant to 2,4-D when 4 to 8 inches high; severe injury may occur from treatments applied to sorghums less than 3 inches high or during advance stages of growth. The most common injury is brace root malformation that may or may not lower yields. Severe injury is characterized by late maturity, dwarfing of plants, sterility and possible death of young plants. The forage sorghums appear to be more resistant to 2,4-D than the grain types. Some grain sorghum varieties are more susceptible to 2,4-D than others. When 2,4-D is used on sorghums only the minimum dosage necessary for weed control should be applied.

Soybeans and Peas

Soybeans. There are several cultural practices that are useful in controlling weeds in soybeans. Delayed planting combined with early seedbed preparation and frequent cultivation to kill weeds until the planting date are successful in reducing the weed hazard. Cultivation of soybeans in rows may reduce the weed population as compared to solid seeded beans.

Chemical weed control in soybeans has not been fully dependable. There are no post-emergence sprays recommended for soybeans but pre-emergence treatments offer possibilities. DNBP at 4 to 8 pounds per acre has given the most consistent results as a pre-emergence herbicide for soybeans. CIPC at 4 to 8 lb. has also given good results as a pre-emergence treatment. The lighter rates of each chemical are recommended for the lighter type soils. As with all pre-emergence herbicides, the results will vary with weather conditions.

Peas. Weed control in canning peas is usually accomplished by thorough seedbed preparation prior to planting. Annual broad-leaved weeds may be controlled when in the 2- to 4-leaf stage by applying from 3/4 to 1 pound per acre of DNBP as an amine salt in approximately 40 gallons of water.

Broad-leaved annual weeds may also be controlled by applying from 2 to 6 ounces per acre of MCP amine or sodium salt to peas between 3 to 7 inches in height.

Sugar Beets

Recommended crop rotations and methods of cultivation suited to conditions within the particular sugar beet growing area are the principal means of weed control.

Where annual grasses (except for wild oats, Avena fatua) are known to be a problem the application of 5 to 7 pounds per acre of TCA just before the emergence of the beets is recommended.

If weather makes it impossible to apply the spray before emergence of the crop, it is best to wait ten days. TCA at the above rates may then be used to control annual grasses. Some beets will be stunted. This should be considered an emergency treatment only.

Selective control of certain broad-leaved weeds may be obtained by the application of sodium chloride (NaCl). From 200 to 300 pounds per acre in 100 to 200 gallons of water, applied when the beets have 2 to 4 true leaves is required. This treatment is not effective on lamb's quarters and purslane. Recommendations for the particular beet growing area should be followed for all above methods.

On moist soil or on areas which can be irrigated, pre-planting applications of from 3 to 5 pounds of IPC per acre, disced into the soil before planting, may be used to control wild oats.

Forage Legumes

Seedling legumes generally are slow growers and thus are poor competitors with weeds. Management practices in preceding crops to prepare land as weed free as possible for legume seedings are desirable. Such practices as use of intertilled crops and after-harvest tillage in seasons preceding legume establishment are suggested. Clipping of seedling legume stands (except sweet clover) when sown alone and mowing the stubble of companion crops, if done low enough and late enough to kill most of the annual weeds, and patch mowing for perennial weeds are practices having merit for weed control in seedling legumes.

The use of herbicides on seedling legumes is to be avoided unless the crop is seriously threatened by weeds. When weeds are a serious problem, seedling stands of ladino clover, alsike clover, red clover, alfalfa, and lespedeza may be sprayed with the sodium or amine salts of 2,4-D or MCP at rates of 1/4 lb. or less per acre without serious losses of legume stand. Sweet clover usually will not tolerate either 2,4-D or MCP application. The dinitro sprays also may be used on these legumes for control of very small annual weeds, but results are highly dependent upon weather. The amine salt of DNBP at rates of 3/4 to 1 lb. in 25 to 40 gallons of water per acre is suggested. With high temperatures and/or humid conditions, use lower amounts of DNBP. TCA at 5 to 7 lb./A. may be used to control many annual grasses in seedling stands of alfalfa and sweet clover, but cannot be used when wheat, oats, or barley is used as a companion crop. TCA cannot be used on alsike and red clovers. Less injury to the legume is produced if the companion crop and/or weed canopy is 10 to 15 inches high.

The use of 2,4-D or MCP on established legumes must be considered as an emergency weed control measure. These herbicides applied other than in the early dormant stage of the legume or immediately after hay harvest usually result in serious yield losses and have often caused stand losses. The dinitro products may be used on established legume stands as listed above for seedling legumes. Established stands of alfalfa and sweet clover may be sprayed with TCA at 5 to 7 lb. per acre for control of many annual grasses without permanent injury to the legumes. Alsike and red clovers should not be sprayed with TCA.

Pasture and Range Grasses

Good management and controlled grazing are of first importance in any attempt at weed control in pasture land.

In very weedy pastures where good perennial grasses are thin, reseeding may be the most important improvement practice. To be successful, a good, firm seedbed should be prepared for any reseeding and fertilizer needs should be taken care of at time of seedbed preparation. Protect new seedlings from grazing until established and graze moderately thereafter. Plowing and seeding to adapted grass where practicable, will almost eliminate many of the perennial pasture species. This practice supplemented by 2,4-D treatment has given better control to all weedy species than either 2,4-D or mowing treatments in one reported experiment.

Mowing has been the recommended practice for controlling many kinds of weeds if done at the right time for 2, 3 or 4 years. In general, mow such herbaceous weeds as ironweed and ragweed when in bud to bloom stage.

Spraying with 2,4-D, 2,4,5-T or a mixture of the two gives better control of more kinds of weeds by a single application than is obtained by a single mowing treatment. Spraying during active growing condition of the weeds gives best results. Repeated treatment for two or more years is usually necessary. Increased production of desirable forage and improvement in grass stands following treatment has been reported. In general, these materials may be used at rates necessary for weed or brush control without appreciable injury to the grasses. While these materials may eliminate some legume species, other native and introduced legume species have a relatively high tolerance to some of the growth regulators.

Seedlings of perennial grasses may be advantageously treated with 2,4-D if the broad-leaved weeds are a problem and if the land is not heavily infested with seeds of the weedy annual grasses. Rates up to 3/4 pound ester per acre may be used after the grass seedlings have reached the 2- to 4-leaf stage of growth.

Control of Weeds in Horticultural Crops

By the wise use of chemicals, it is possible to reduce greatly the cost of weeding many horticultural crops and to save some crops when wet weather makes it impossible to cultivate. However, chemical weed control must not be considered as a substitute for all cultivation but rather should be used to supplement standard cultural practices. There are many herbicidal treatments in addition to those listed here that may be valuable in certain localities. Only those that are of regional interest have been included in these recommendations. For other possible treatments local authorities should be consulted.

All rates of application are based on over-all coverage. It is often more economical to treat only a narrow strip over the row, in which case the application should be reduced accordingly.

Vegetable Crops

Asparagus. The common practice in most areas is to disc asparagus beds in early spring to loosen the soil, destroy weeds and to remove the old ferns. After discing and before spears have emerged, 2,4-D may be applied at the rate of 2 pounds or SES at 4 to 6 pounds per acre as a pre-emergence spray for the control of broad-leaved weeds. If annual grasses are a problem 5 to 8 pounds of TCA may be added to the 2,4-D or SES spray. DNBP at 6 to 8 pounds and N-1 naphthyl phthalamic acid at 4 to 8 pounds per acre have also been used successfully at this time for the control of both annual grasses and broad-leaved weeds.

Following the post-harvest discing, the above rates of 2,4-D, SES, DNBP, or N-1 naphthyl phthalamic acid may be used before any spears are showing. It is not known at present whether TCA may be safely used after the cutting season. Present evidence indicates that it is wise to apply 2,4-D only once during any season.

CMU at rates of 1 to 2 pounds per acre has given good results as a pre-emergence treatment in experimental trials--the higher rate is for high organic soils. Since tests have not been conducted long enough

to determine the possible accumulative effect over a period of years, it is suggested for trial use only.

The use of Stoddard solvent at 80 to 100 gallons, DNBP at 1 pound or 2,4-D at 1 pound per acre are recommended for contact pre-emergence treatment to control weeds in asparagus seedbeds.

Beans. In most residual pre-emergence sprays to control weeds in the row together with cultivation between the rows has proven quite successful. A smooth well-prepared seedbed is of inestimable value where pre-emergence sprays are used.

Six to 9 pounds of DNBP or 15 to 25 pounds of sodium PCP per acre of actual sprayed area will control most annual weeds for a considerable period. The higher rates should be used where sprays are applied very soon after planting. When sprays are delayed until shortly before bean emergence, at which time many weeds may have emerged, the lower rates may be used with equal effectiveness. Where very serious infestations of annual grasses threaten, it may be necessary to apply in excess of the highest rate suggested above. Optimum concentrations of the above chemicals which may be used on various soil types without injury to the crop must be determined by preliminary field trials. Both of these herbicides may cause injury when temperatures are high.

Beets. For annual grasses, a residual pre-emergence spray of 8 to 10 pounds per acre of TCA has provided excellent control. For best results the land should be well prepared by the removal of as many lumps and clods as possible. There appears to be some advantage in the control of grasses and a few small broad-leaved weeds if the spray is applied 3 to 4 days after planting.

If weather makes it impossible to apply the spray before emergence of the crop, it is best to wait 10 days. Ten pounds of TCA may then be used to control grasses only. Some beets will be stunted. This should be considered an emergency treatment only.

Cabbage, Cauliflower and other Vegetables of the Genus Brassica. When any of these crops are direct-seeded a pre-emergence spray of 5 to 8 pounds per acre of TCA may be used to control annual grasses.

Carrots, Celery, Dill, Parsnips, and Parsley. Small annual weeds may be controlled on muck and upland soils with applications of stoddard solvent at the rate of 80 to 100 gallons per acre if the entire area is sprayed. The quantity may be reduced substantially if only a narrow band over the row is treated. The sprays should be applied when most of the first crop of weeds has emerged but before any of them are more than two inches tall.

Maximum effectiveness may be obtained, and in some instances with lower rates, by applying the chemical at night when air movements are down and the relative humidity is high. Early evening applications before the dew has formed may prove most satisfactory in those areas where exceptionally heavy dews may cause excessive run-off of the chemical later at night.

Carrots and parsnips should not be sprayed after the tap root is more than one-fourth inch in diameter or after five or more leaves are present. Stoddard solvent may be applied to celery only in the seedbed.

Onions. For the control of weeds that have emerged before the onions, stoddard solvent at 40 to 80 gallons per acre, or 3 to 5% sulphuric acid at 100 gallons per acre can be used as pre-emergence sprays. On those muck soils on which the smartweeds (Polygonum sp.) or purslane (Portulaca oleracea) are the principal weed species CIPC at 6 to 8 lb. is recommended.

For the control of weeds in onions in the "loop" stage or after the first true leaf is at least two to three inches long, post-emergence sprays of two to three per cent sulphuric acid at the rate of 100 gallons per acre, or potassium cyanate at 12 to 16 pounds in 50 to 100 gallons of water per acre is recommended. Purslane is controlled only in the cotyledon stage and lamb's quarters and grasses are usually not killed.

For the control of weeds in onions having three to five leaves but before they are "laid by" basal applications of 3 to 4 per cent sulphuric acid at 100 gallons per acre, 16 to 20 pounds of potassium cyanate or 8 pounds of CIPC in 50 to 100 gallons of water per acre is recommended. The CIPC treatment is particularly effective for the residual control of smartweeds (Polygonum spp.) and purslane (Portulaca oleracea). All such sprays should be applied so as to avoid hitting the tops of the onion plants.

In older onions which are bulbing and which have been "laid by", the use of basal sprays of herbicide to control late germinating weeds such as purslane is recommended. Three to four per cent sulphuric acid at 100 gallons per acre or DNBP at 1 to 1 3/4 pounds per acre in 50 to 100 gallons of water are effective if applied when weeds are small. On muck soils, 2 lb. of CMU can be similarly used. All such sprays should be applied so as to avoid hitting the tops of the onion plants either by using shields over the spray nozzles or over the onion row, or by the use of drop nozzles.

Potatoes. While blind cultivation is generally preferred to control weeds before the emergence of potatoes, in wet weather chemical treatments may be valuable. 2,4-D at 1 to 2 pounds, DNBP at 3 to 6 pounds, and sodium PCP at 10 to 20 pounds per acre have all given good results when applied 2 to 6 days before emergence. Where annual grasses are a problem TCA at 8 to 10 pounds per acre may be used as a pre-emergence spray. Local recommendations should be followed as regards differences in varietal susceptibility when 2,4-D is used.

If, following mechanical vine destruction, adverse weather interfers with digging, annual grasses may present a problem. In such cases, DNBP at 1.25 to 1.87 lb. in 5 to 10 gallons of oil per acre will check the growth of weeds and weedy grasses. The chemical treatment alone will not ordinarily be sufficient where there is a normal vine growth.

Sweet Corn. 2,4-D can be used in sweet corn as recommended for field corn.

Direct-seeded tomatoes. Where a large number of weeds come up before the tomatoes, stoddard solvent may be applied at 50 gallons per acre about 2 days before the tomatoes start to emerge. Where annual grasses make up most of the weed population, a pre-emergence treatment of TCA at 3 to 4 pounds per acre two days before emergence has given good results.

Vine Crops. Weeds in cucumbers, muskmelons and watermelons have been controlled successfully

with N-1 naphthyl phthalamic acid. It may be applied as a pre-emergence treatment immediately after planting these crops at from 2 to 3 pounds per acre on light sandy soils, 3 to 4 pounds on light-colored loams or 4 to 6 pounds on heavy or dark-colored soils. It can also be used as a post-emergence spray where these crops are grown from transplants. In this case the rate of application should not exceed 4 pounds per acre. N-1 naphthyl phthalamic acid should not be applied to extremely early plantings of vine crops when the soil is cold.

Certain varieties of pumpkins and squash are less tolerant to this herbicide than the other vine crops. They should be sprayed only in accordance with local recommendations.

Seedbeds and plantbeds. Weeds can be controlled in seedbeds and plantbeds with steam sterilization or fumigation with methyl bromide.

Waste places adjacent to vegetable fields. Weeds along drainage ditches and fence rows, around buildings, under irrigation lines, and other waste places can be effectively controlled with oils, DNBP, PCP and TCA.

Small Fruits, Ornamental Shrubs and Flowers

Brambles. Weeds within the plant row of brambles grown in a hedge row or linear system cannot be controlled by any implement. A deep mulch of sawdust, shavings, ground corn cobs, or straw helps measurable in the control of these weeds but the cost may be prohibitive under certain conditions and, moreover, the mulch presents certain hazards. Weeds will grow through these materials in time.

Sodium 2,4-dichlorophenoxyethyl sulfate (SES) is effective as an herbicide for use in raspberries. It can be used at the rate of 3 to 6 lb. per acre at any season without injury to canes, foliage, new shoots or fruits. To be effective this chemical must be applied before weeds emerge from the soil. SES will be more effective against broad-leaved weeds than grasses.

This crop is somewhat tolerant of 2,4-D and DNBP. Basal directed sprays of these chemicals, if carefully applied with low pressure equipment, will not damage the canes and will control many species of weeds. The first application should be made early in the spring before the weeds and new bramble shoots emerge. The second application should be delayed until the new bramble shoots are tall enough to permit the spray operation without hitting the tips which are easily injured. 2,4-D in the salt form should be used at 1/2 to 3/4 lb. per acre for the early spring application. For the later application 1/2 lb. of the chemical should be used. Do not use the ester form of 2,4-D in raspberries. Do not use 2,4-D during the blooming stage. DNBP can be used at 2 to 4 lb. per acre. Use the higher concentration for the early spray and the weaker rate for the later sprays when the newly-emerged canes are tender. A minimum amount of spray should contact the base of the canes. DNBP must be applied while the grasses and broad-leaved weeds are small.

Strawberries. In most seasons weeds in newly set strawberry fields can be controlled by mechanical cultivation up until the time that runner plants begin to set. After this time considerable hand labor is required to keep the row free of weeds. Strawberries are somewhat tolerant to hormonal type herbicides and 2,4-D and sodium 2,4-dichlorophenoxyethyl sulfate (SES) are the most promising herbicides for use in this crop.

Pre-planting treatments with 2,4-D (amine salt) have shown promise at the rate of 2 to 3 pounds per acre (higher rates for clay soils and soils high in organic matter and lower rates for sandy soils) where the soil is disturbed little in the planting operation. 2,4-D may be used as a selective foliage spray at the rate of 1 lb. per acre during the period from 3 to 4 weeks after setting until late August when fruit bud differentiation begins. Treatment at the time of runner initiation usually causes a marked inhibition of runners.

To be effective against grasses 2,4-D must be applied no later than the germination stage. For the control of over-wintering weeds 2,4-D at the rate of 1½ pounds per acre has given excellent control of susceptible weeds. Application, however, must be delayed until after the period of fruit bud differentiation to prevent fruit deformity.

One pound or less of 2,4-D may be used at the time of mulch removal if overwintering weeds were not controlled in the late fall. One pound of 2,4-D per acre may be used just before the fruit begins to ripen as an emergency measure if annual broad-leaved weeds threaten to take the field. 2,4-D must not be applied during the blooming period. This material has an important place in weed control the second summer and can be used at the rates of 1½ to 2 pounds per acre.

Sodium 2,4-dichlorophenoxyethyl sulfate (SES) is an effective herbicide only after it has been changed to an active form in the soil by the micro-organisms. Due to the nature of this material it is less injurious than 2,4-D to the strawberry plants but it is effective against weeds only in the germinating seedling stage. This material may be used immediately after setting at the rate 3 to 6 lb. per acre but the preferred time of application is 2 to 3 weeks after the plants are set. Excellent weed control for three weeks or longer is usually obtained. Repeat applications may be made during the spring, summer, and fall months as needed. Runner production is reduced only slightly at these rates. It appears safe to use during the critical period of fruit bud differentiation; however, further investigational work should be done with this material at this stage of growth.

Herbicides may be applied to the whole field or applied only in a band over the row. Rates of application are based on the area sprayed and the actual amount of chemical applied will be ½ or less of the per acre rate in the case of band applications.

Grapes. Where weeds beneath the trellis cannot be controlled effectively by the grape hoe they may be controlled by treatment with contact herbicides such as oil emulsions fortified with DNBP or PCP. Use 2 lb. of DNBP, 15 gallons of aromatic or fuel oil and make up to 100 gallons with water. Four pounds of PCP may be substituted for the DNBP in the above mixture. Use a suitable emulsifying agent and make certain that the oil remains emulsified. Apply at the rate of 50 gallons per acre in an 18 inch strip beneath the trellis. Use a low pressure sprayer with a fan type nozzle. Keep the spray off the foliage and do not spray young vines which are not yet protected by a coating of loose bark.

Grapes are extremely sensitive to hormonal type herbicides such as 2,4-D.

Gladiolus. Pre-emergence treatments of 2,4-D (ester or salt) at 2 pounds per acre, DNBP at 8 pounds per acre, and sodium 2,4-dichlorophenoxyethyl sulfate (SES) at 3 to 6 pounds per acre will control most annual broad-leaved weeds. Where annual grasses are the primary problem TCA, at 10 pounds per acre, can be used. If both types of weeds are present a mixture of 2,4-D and TCA may be used.

Post-emergence treatments with 2,4-D (salt), at the rate of 1 pound per acre, when the gladiolus are six inches tall or before the leaf blades open, controls most of the weeds in the row. Considerable injury may result if higher concentrations of 2,4-D are used and if the plants are treated in their later stages of growth.

Recent experiments indicate that SES is less injurious than 2,4-D and can be used pre-emergence at the rate of 3 to 6 pounds per acre and post-emergence at similar rates.

Cormels grown for size increase are more subject to injury than flowering size corms.

Nursery Stock. For transplant beds and seedling beds, methyl bromide and other soil fumigants may be used. Stoddard solvent or equivalent aromatic oils may be used as a contact herbicide for the control of broad-leaved weeds and annual grasses in coniferous seedling and transplant beds. The rate of application varies from 25 to 75 gallons per acre depending on the species and the growth stage of the seedling at the time of treatment.

For coniferous transplants and deciduous stock in rows, aromatic oils fortified with PCP or DNBP may be used between the rows. A low pressure sprayer with a hooded boom should be used to prevent drift. Because of the oil in the mixture, application to the base of the stem should be avoided.

Considerable hand labor can be saved by planting lining-out stock on the square to permit cross cultivation.

TCA is recommended for use in the control of quack grass. Soil applications heavy enough to control the quack grass may be applied the season before planting coniferous seeds.

SES is a promising herbicide for use in many species of ornamental plants at specific stages of growth. Depending upon the species, there are several times during the season when the chemical may be applied. In general, the herbicide has not been satisfactorily employed for weed control during the cool temperatures which prevail prior to May 15 in the North Central region. The large number of species found in our nurseries has made it impossible to test all of them for tolerance to SES to date. Consult your own experiment station for information on the tolerance of the individual species and the proper amount of chemical to use on your soil type.

CIPC may be used at the rate of 6 lb. per acre in October in newly established apple stool blocks. It may also be applied to mature stool blocks after cutting and leveling in November.

Turf

Broad-Leaved Weeds. Control of annual broad-leaved weeds in new turf can be obtained by ordinary mowing and management practices which favor the development of good turf grasses. Herbicidal sprays should not be applied until the turf is one year old.

In established turf certain perennial weeds can be controlled by applications of 2,4-D made when the weeds are in active growth. Periods of active growth, in most of the North Central Region, occur in both spring and fall. Because of less risk of injury from drift to adjacent ornamental plantings, fall applications are generally preferred. The amine salt of 2,4-D at a concentration of 0.1 to 0.2 percent acid equivalent, and a volume of 1 gallon per 1000 square feet, is adequate for many species. Better results on resistant species will be obtained when 2,4-D esters are used but more damage from drift or volatization may occur.

Crabgrass. May be controlled by either of the following methods:

(1) Potassium Cyanate, 3 ounces per 1000 square feet, preferably when crabgrass seedlings are not more than 2 inches in height. Repeat applications at 7 to 10 day intervals may be required.

(2) PMA, 0.3 ounce per 1000 square feet, as soon as crabgrass seedlings are observed. The application must be repeated at 7 to 10 day intervals until 3 to 5 applications have been made.

Aerial Spraying

Aerial applications of herbicides are recommended as economically advantageous and often more effective than other methods under many conditions. Factors to be considered in determining these advantages are: size of area to be sprayed, time available for treating a given area, inaccessibility of the area to other equipment, suitable weather conditions, proximity of other crops which may be damaged by drift, comparative results and costs of aerial applications as against results and costs of other methods.

The most advantageous use of aerial spraying at present is for brush control (mesquite, sagebrush, oak brush and others), for weed control in small grains, pastures, ranges and other large areas and for pre-harvest defoliation and desiccation.

Even distribution is essential in all herbicide applications and a minimum of drift is desirable. Therefore, the swath width should be 40-45 feet or less and the altitude should be as close to the foliage as safety of the pilot and equipment will permit (boom 4 to 5 feet above foliage on flat terrain and even growth; more clearance as necessary on uneven growth and terrain). The plane should be operated crosswind in order to maintain constant ground speed; but where it is necessary to fly parallel to the wind, it is desirable to fly upwind only.

Spraying should be done when the wind velocity is as low as possible. The following wind velocities are suggested as maximums for these representative conditions:

2,4-D in mixed farming area at 1 - 2 gal/acre
wind velocity 5 mph
2,4-D in mixed farming areas at 5 gal/acre
wind velocity 8 mph
2,4-D in range country at 1 - 2 gal/acre
wind velocity 8 - 10 mph

Chemical desiccants anywhere at 5 - 8 gal/acre
wind velocity 8 - 10 mph

If aerial spraying is recommended in areas where susceptible crops are grown, only low volatile materials should be employed.

Large droplets minimize probability of drift, therefore, large orifice nozzles should be used. Each nozzle should be equipped with a positive shutoff. Light oil diluents break up in finer droplets than water because of lower surface tension, therefore, water or emulsions should be considered where drift presents a hazard.

Many chemicals settle out of solution or emulsion when allowed to stand so each plane load should be mixed just prior to take-off or the spray solution in an auxiliary tank should be thoroughly agitated before each plane load is removed from it. It is desirable that each plane have positive agitation equipment in the tank.

It is recommended that all owner-operators and pilots be familiar with the character of the chemical being used. Owner-operators should exercise close control over the operation of their planes. In the interests of safe operation, each plane should be equipped with all of the safety equipment (helmets, masks, dump valves, etc.) which is necessary.

The following are considered desirable features of aerial spray equipment:
Tank: The spray tank should be of light weight material; aluminum and stainless steel are preferred for corrosion resistance. It should have a large filler opening to allow for easy cleaning and filling and have baffles to prevent surging.
Pump: Positive displacement pumps of the gear type produce high pressures and require a relief valve while centrifugal pumps with lower maximum pressures do not need a relief valve and are capable of handling suspensions. Pumps driven by external fans need a brake assembly and those engine-driven require a clutch.
Booms: Streamlined booms produce less drag than round ones; all booms should be fitted with caps at the ends for cleaning. The boom should have fewer nozzles in the 3 to 4-feet space left of center and more nozzles to the right of center to overcome spray displacement caused by propeller slip stream.

Desiccation, Defoliation and Pre-Harvest Weed Control

General: The presence of weeds and green crop material in many crops at harvest time frequently complicate harvest operations and result in considerable loss of seed. Experiments in the North Central Conference area have been rather limited in this field, and in view of this the following suggestions are offered:

Flax. 1.25 to 1.87 lb. of DNBP or 2 to 4 lb. of PCP applied in 5 to 10 gallons of diesel fuel per acre have given satisfactory drying of flax. Also suggested for limited trials is 1.25 lb. Endothal plus 6.25 lb. of ammonium sulphate in 20 gallons of water per acre.

Soybeans. The same materials and rates that are recommended for flax are suggested. Treatment should be applied when the beans are nearly mature, or some reduction in yield and quality may be expected.

Alfalfa and Clovers. Recommended treatments are DNBP at 1.25 to 1.87 lb. in 5 to 10 gallons of diesel fuel per acre or PCP at 4 to 6 lb. in 5 to 10 gallons of diesel fuel per acre. If weedy grasses are present, 1 lb. of Endothal with 4 lb. of ammonium sulphate in 20 to 30 gallons of water per acre may give more satisfactory results than the above mentioned treatments.

Mechanical Considerations

Mechanical considerations of a good program of weed control include the use of seed cleaning, tillage, chemical spraying and harvesting equipment. There is no one machine in the above group which will give good weed control when used exclusively with no regard to the other. It is recommended that all of these implements be included if possible in setting up the weed control program.

Seed cleaning. It is highly recommended that all seed used be free of weed seed. The absence of weed seed in the planting will be reflected in less work for the tillage and chemical practices which follow and will avoid the introduction of new weed species.

Tillage equipment. The effectiveness of tillage operations is dependent upon the timing, speed and adjustments of the implement. It is recommended that all three variables be given careful consideration in connection with soil type, conditions and crop.

The adjustment of the implement is especially important in the use of the cultivator, in that it should give as much weed control as possible within the crop row and yet should avoid injury to the plant or pruning of the roots. It is recommended that floor line diagrams be used for making proper spacing and depth adjustments of tillage implements.

Sprayers. In the acquisition of a farm weed sprayer, careful consideration should be given to its selection, service and possible repair. For this reason it is recommended that dealings be made only with reputable dealers and manufacturers capable of furnishing service and parts when needed.

In the selection of a weed sprayer, thoughtful consideration should be given to other pest control operations likely to require use of a sprayer around the farm, with such consideration being of special value in the choice of the pump and the sprayer mounting.

Attention should be directed to the choice of equipment constructed of materials which are resistant to corrosion by the common herbicides. It is also recommended that attention be given to the use of materials, coatings, hose and gasket material which are unaffected by the oils and solvents used with these herbicides.

Some of the desirable features of a good weed sprayer are as follows:

Tank: The tank should be strong enough to withstand the pressure of the fluid splashing around inside and should be of a size compatible with the discharge of the pump and the operations under consideration. An opening should be provided which will allow for cleaning the inside when necessary. Provisions should be included for draining. In view of recent knowledge of herbicides, it is important that a method be provided for agitation within the tank either by mechanical means or by sufficient by-pass from the pump.

Suction Strainer: This strainer should be fine enough to remove as much foreign material from the solution as possible and of sufficient size so as not to throttle the suction action of the pump. Inasmuch as this requires a compromise, special emphasis should be put on precautionary measures at the time the tank is being filled. It should be easily removable for cleaning when and if necessary.

Pump: The pump should be of sufficient capacity and quality to maintain adequate working pressure and flow to meet the particular conditions set by the spraying operation. An important point to consider in the case of power take-off pumps is maintaining the pressure and flow at reduced PTO speeds when used with some tractors where the choice of gear and speed may require operation at less than full throttle.

Regulating valve and pressure gauge: These two items which are closely associated should be within easy reach and sight of the operator. The marked increments of the gauge should be considered with respect to the spraying operation.

Boom: Booms should be of adequate strength and be adequately hinged to prevent breakage and to permit convenient transportation. They should be of large enough diameter and of adequate size to prevent a significant pressure drop at the end nozzles. In view of the concentrations at which many herbicides are used, special care and attention should be given to the selection and performance of the nozzles.

Other features essential to a good sprayer are quick acting shut-off valve, line filter between the pump and boom, individual filters at each nozzle and some device for measuring the fluid in the tank.

Calibration: It is recommended that the sprayer be calibrated to each particular operation. The best method of calibration being the making of initial adjustments to suit the machine and job requirements, then making a trial run to determine the actual output and mixing the herbicide accordingly. This calibration should be checked frequently during the operation to correct for such things as nozzle orifice wear and is especially important when abrasive solutions are used.

Maintenance: A strict cleaning program should be followed after each use of the sprayer. This should include not only flushing the tank, pump, boom, and nozzles, but also the exterior of the equipment. When the sprayer is prepared for winter storage, all bare metal parts should be coated with oil. As an added precaution, pumps should be left disassembled during any long storage.

Harvesting equipment. It is recommended that that for each piece of harvesting equipment a strict individual cleaning program be set up and adhered to before moving the machine from place to place.

Abbreviations Defined

2,4-D - 2,4-dichlorophenoxyacetic acid
MCP - 2-methyl-4-chlorophenoxyacetic acid
2,4,5-T - 2,4,5-trichlorophenoxyacetic acid
TCA - trichloroacetic acid
PCP - pentachlorophenol
DNBP - 4,6-dinitro-o-sec-butylphenol
NP - N-1-naphthyl phthalamic acid
PMA - phenyl mercuric acetate
IPC - isopropyl-N-phenylcarbamate
CIPC - isopropyl-N-(3 chlorophenyl) carbamate
CMU - 3-P-Chlorophenyl-1-1-dimethylurea
Endothal - 3,6-endoxyhexohydrophthallic acid
SES - sodium 2,4-dichlorophenoxyethyl sulfate
MH - maleic hydrazide
KOCN - potassium cyanate

RECOMMENDATIONS OF THE COMMITTEE ON TERMINOLOGY

The committee recommends the use of the terms, definitions, and abbreviations listed in this report in the preparation of abstracts, reports, and articles that have to do with weed control. The use of the recommended forms, definitions, etc. is especially desirable in the preparation of short reports in order to conserve space and to make for easier interpretation of results by project leaders and readers in general.

Trade Names and Code Numbers usually should not be used. The Research Committee has ruled that reports on materials by code number or trade name only shall not be used in preparing summaries. Some highly complex organic herbicides have been introduced under trade names. As long as these products are made by only one company, the trade-marked names (always capitalized) may be used in the body of an article or abstract. The first time such a product is mentioned in a research report, the full chemical name should be given, followed by the trade name in parentheses.

Chemical Names and Designations. Chemical symbols should not be combined with alphabetical abbreviations in designating compounds, for instance, the sodium salt of TCA should not be stated as NaTCA. In the list which follows, the chemical name is given in (a) followed in (b) by common names of basic compounds (c) common derivatives of basic compound.

Rates and concentrations for materials listed in items, 1,2,3,4 and 5 should be stated as the acid equivalent.

1. (a) 2,4-dichlorophenoxyacetic acid
   (b) 2,4-D
   (c) 2,4-D,salt (indicate which)
   2,4-D,ester (indicate which)

2. (a) 2,4,5-trichlorophenoxyacetic acid
   (b) 2,4,5-T
   (c) 2,4,5-T,salt (indicate which)
   2,4,5-T,ester (indicate which)

3. (a) 2-methyl-4-chlorophenoxyacetic acid
   (b) MCP
   (c) MCP,salt (state which)
   MCP,ester (state which)

4. (a) trichloroacetic acid
   (b) TCA
   (c) TCA,salt (state which)

5. (a) N-1-naphthyl phthalamic acid
   (b) NP
   (c) NP,salt (state which)

Rates and concentrations for materials listed in items 6, 7, 8 and 9 should be stated as the phenol equivalent.

6. (a) pentachlorophenol
   (b) PCP

(c) PCP, sodium salt (rates have usually been stated in terms of the salt)

7. (a) 4,6-dinitro-o-cresol
   (b) DNC
   (c) DNC, salt (state which)

8. (a) 4,6-dinitro-o-sec-butylphenol
   (b) DNBP
   (c) DNBP, salt (state which)

9. (a) 4,6-dinitro-o-sec-amylphenol
   (b) DNAP
   (c) DNAP, salt (state which)

Rates and concentrations for all the following materials should be stated as pounds or ounces of active ingredient.

10. (a) phenyl mercuric acetate
    (b) PMA

11. (a) isopropyl-N-phenylcarbamate
    (b) IPC

12. (a) isopropyl-N-(3-chlorophenyl) carbamate
    (b) CIPC

13. (a) 3-p-chlorophenyl-1-1-dimethylurea
    (b) CMU

14. (a) 3,6-endoxohexahydrophthallic acid
    (b) endothal

15. (a) sodium 2,4-dichlorophenoxyethyl sulfate
    (b) SES

16. (a) potassium cyanate
    (b) KOCN

17. (a) Maleic hydrazide
    (b) MH

All other compounds should be listed by their full chemical names.

DEFINITIONS

1. Pre-emergence applications are those made after crop is planted but before it emerges and are of two kinds: (1) contact pre-emergence - an application made after weed emergence and (2) residual pre-emergence which kills weeds as the seed germinates or as they emerge either before or after the crop has emerged.

2. Soil sterilant. A material which renders the soil incapable of supporting plant growth. Sterilization may be temporary or relatively permanent.

3. Contact herbicide. An herbicide that kills primarily by contact with plant tissue rather than as a result of translocation.

4. Low volatility, as applied to herbicides such as 2,4-D, 2,4,5-T and other similar compounds, is a relative term. Differences in volatility are real and important, but so far, can be determined only by biological tests.

5. Low volatile esters. The esters of 2,4-D, 2,4,5-T and other similar herbicidal compounds that have low volatility should not be designated as non-volatile esters.

6. Spray drift. The movement of airborne spray particles from the spray nozzle outside the intended contact area.

7. Vapor drift. The movement of herbicidal vapors from the area of application to adjacent areas.

8. Rate and dosage. These terms are synonomous. Rate refers to the amount of active material (such as 2,4-D acid equivalent) applied to a unit area (such as one acre) regardless of percentage of chemical in the carrier.

9. Concentration. Refers to amount of active material in a given volume of diluent. Recommendations and specifications for concentration of herbicides should be on the basis of pounds per unit volume of diluent.

10. Herbicide. A chemical known to be toxic to some chlorophyll-bearing plants.

11. Dormant treatment of deciduous woody plants refers to applications of herbicides made during the period after leaf-fall, or death of leaves, and before bud-break.

12. Basal treatment. A basal treatment is an application to the stems of plants at and just above the ground line.

13. Alphabetical designations for chemical compounds should be capital letters (upper case) without spacing or periods; for example MCP, PCP.

ABBREVIATIONS

The use of the following abbreviations is recommended and, unless otherwise indicated, should be small letters (lower case) without spacing or periods:

acid equiv. per 100 gal.	ahg
acre	A
bushel or bushels	bu
diameter	diam
foot or feet	ft
feet per minute	fpm
parts per million	ppm
pint or pints	pt
pound or pounds	lb
pounds per sq. in	psi
quart or quarts	qt
rate per acre gal/A, oz/A, lb/A,	bu/A
gallon or gallons	gal
inch or inches	in
miles per hour	mph
revolutions per minute	rpm
square	sq
weight	wt

FIRST NATIONAL WEED CONTROL CONFERENCE

December 8, 9, 1953

and

10TH ANNUAL NORTH CENTRAL WEED CONTROL CONFERENCE

December 10, 1953

RESOLUTIONS

The Resolution Committee moves the adoption of these resolutions and hereby instructs the Secretary to take appropriate action.

WHEREAS, the untimely passing of Mr. L. S. Evans formerly Project Analysist in the Office of the Chief, B.P.I.S.A.E. has deprived the entire weed control research program a valued and competent research administrator and whereas this Weed Control Conference recognizes its severe loss of a sincere friend and a devoted co-worker,

NOW, THEREFORE, BE IT RESOLVED that we express our heartfelt sympathy to his wife and children.

WHEREAS, the North Central Weed Control Conference is indebted to Dr. Alfred P. Haake, and

WHEREAS his stimulating and entertaining contribution to our Tenth Annual Meeting was greatly appreciated.

NOW, THEREFORE, BE IT RESOLVED that we express our thanks and appreciation to the General Motors Corporation in making it possible for Dr. Haake to be with us.

WHEREAS, Dr. Henry L. Bolley, pioneer investigator in chemical weed control, long ago recognized the potential value of this aid to agriculture, and

WHEREAS many of his observations, predictions and recommendations have been borne out in recent years,

NOW, THEREFORE, BE IT RESOLVED that the Tenth North Central Weed Control Conference, meeting in Kansas City, Missouri, December 10, 1953, commend Dr. Bolley for his leadership and enthusiasm in the aspect of crop production.

WHEREAS, noxious weed control is a state, county and community problem, and

WHEREAS, noxious weeds do not recognize geographic boundaries, and,

WHEREAS, states having noxious weed laws expect noxious weeds on lands within their boundaries to be controlled or eradicated, and,

WHEREAS, it is difficult for weed control officials in states where organized weed control is being carried out to obtain full cooperation of their people due to the inability of carrying out weed control on federal lands, and

WHEREAS, weeds now cause farmers an estimated annual loss of four to five billion dollars, and,

WHEREAS, Senate bill S. 627 and House bill H.R. 2115 have been introduced in the 83d Congress and reads as follows: Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That every department, agency, and independent establishment in the executive branch of the Government having control of or jurisdiction over land located in any State shall hereafter comply with all laws and all rules and regulations of such States providing for the control of noxious weeds.

NOW BE IT RESOLVED that this Conference urge members of the United States Congress to use their best efforts in the passage of legislation provided for in S. 627 and H.R. 2115.

WHEREAS, the N.C.W.C.C. has greatly enjoyed and appreciated the excellent facilities provided and the diverse and interesting program arranged

NOW, THEREFORE, BE IT RESOLVED that we express our thanks to

K. P. Buchholtz	R. L. Lovvorn
L. A. Dersheid	C. E. Minarik
J. R. Fleetwood	F. W. Slife
C. J. Gilbert	E. P. Slywester
D. D. Hemphill	and to all others who
O. C. Lee	contributed

LEAF WAXES AND HERBICIDAL SPRAYS

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Abstract

The surfaces of leaves and herbaceous stems are covered with a special protective layer a few microns thick, known as the cuticle. The cuticle is assumed to be composed of pectins, a group of waxes known collectively as cutin, and possibly some cellulose. Many plants, particularly those which develop a "bloom" on the leaves as cabbage or blue spruce, show a considerable accumulation of various waxy materials on the surface of the cuticle.

Electronmicrographs of special replicas of leaf and stem surfaces show that these waxes are extruded through the cuticle, in part through or near pores, and in part more or less at random. These extruded wax threads or columns form varying semi-crystalline, columnar or spongy patterns that are 0.2 to about 1.0 micron in depth. Exposed areas of the cuticle can be seen through the waxy layer.

When water or herbicidal sprays with high surface tensions are sprayed onto these waxy layers, the liquid does not come into contact with the cuticle and dries without penetrating the leaf. Any chemicals present in the water will be deposited on the surface of the wax. If wetting or emulsifying agents are used, as in 2,4-D ester sprays, the solution wets the wax, comes in contact with the cuticle, and chemicals present in the spray will penetrate into the leaf, provided the cuticle itself is not impermeable.

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AND TENTH ANNUAL NORTH CENTRAL

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Associated Sales and Supply Co., St. Louis, Mo.
B. F. Goodrich Chem. Company, Cleveland, O.
California Packing Corporation, Rochelle, Ill.
Chipman Chemicals, Ltd., Winnipeg, Manitoba, Canada
Clark Manufacturing Company, Atherton, Mo.
Columbia-Southern Chemical Corp., Pittsburgh, Pa.
Comfort Equipment Company, Kansas City, Mo.
Consumers Cooperative Association, Kansas City, Mo.
Davey Tree Expert Company, Kent, O.
Delavan Manufacturing Company, W. Des Moines, Ia.
Diamond Alkali Organic Chemicals Div., Inc., Newark, N. J.
Dow Chemical Company, Midland, Mich.
E. I. DuPont DeNemours and Co., Inc., Wilmington, Del.
Evans Orchard Supply Co., Kansas City, Mo.
Fargo Foundry Company, Fargo, N. D.
Farmers Union Central Exchange, Saint Paul, Minn.
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Green Bay Flour and Feed, Inc., Green Bay, Wis.
Green Cross Products, Winnipeg, Manitoba, Can.
Green Giant Company, Le Sueur, Minn.
Gre-Sen Mfg. Company, Minneapolis, Minn.
Hahn, Inc., Evansville, Ind.
Hanson Chemical Equipment Company, Beloit, Wis.
Hypro Engineering, Inc., Minneapolis, Minn.
Illinois Farm Supply Company, Chicago, Ill.
International Elevator Co., Minneapolis, Minn.
International Harvester Company, Chicago, Ill.
John Bean Company, Lansing, Mich.
McConnon and Company, Winona, Minn.
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Monsanto Chemical Company, St. Louis, Mo.
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National Grain Company, Ltd., Winnipeg, Manitoba, Can.
Northrup-King and Company, Minneapolis, Minn.
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Oldbury Electro-Chemical Company, New York, N. Y.
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Pacific Coast Borax Company, Los Angeles, Calif.
Pennsylvania Salt Mfg. Co., Philadelphia, Pa.
Riverdale Chemical Company, Harvey, Ill.
Rohm and Haas Company, Philadelphia, Pa.
Skelly Oil Company, Kansas City, Mo.
Spraying Systems Company, Bellwood, Ill.
Standard Oil Company, Chicago, Ill.
Swift and Company, Chicago, Ill.
The J. C. Robinson Seed Company, Waterloo, Neb.
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Thompson Chemicals Corporation, St. Louis, Mo.
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